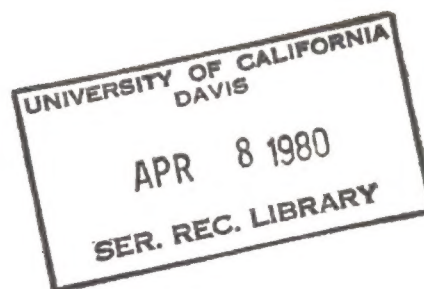
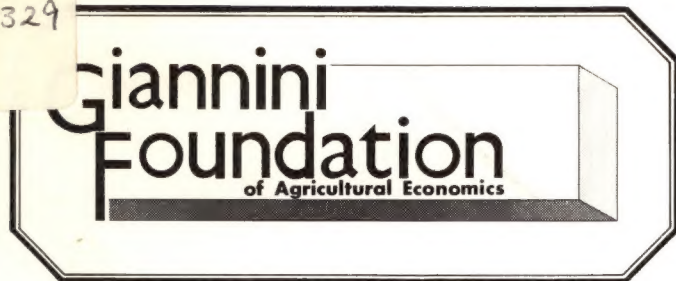


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DEMAND AND LOCATION ASPECTS OF EMERGENCY MEDICAL FACILITIES IN RURAL NORTHERN CALIFORNIA

S. G. Daberkow and G. A. King

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Economic Development Division
Economics, Statistics and Cooperatives Service
U.S. Department of Agriculture

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FOREWORD

Most research of the Agricultural Experiment Station is directed to efficient use of resources in the production and marketing of agricultural commodities. This study illustrates that some of the same techniques can be applied in other areas as well--in this case to the analysis of delivery of services to people in rural areas.

This is an analysis of efficient provision of emergency medical services in a six-county area of Northern California, comprising most of the Superior California Health Planning Area. The California Department of Health has set goals for provision of such care, but has not given full consideration to the cost and location of facilities. The results are presented as a contribution to a more comprehensive analysis of the costs and benefits of provision of emergency medical services. The methodology and a brief review of findings of this study are given in Daberkow and King (1977). The authors express their appreciation to the several reviewers of the manuscript for their suggestions and to the typists for their assistance in preparing the final copy.

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By

S. G. Daberkow^{1/} and G. A. King^{2/}

I. INTRODUCTION

The Problem

Emergency Medical Services [EMS], a subsystem of the general health care sector, has been of increasing concern to legislators and governmental agencies. Willemain [1974, p. 4] has presented the goals of an EMS subsystem in terms readily recognizable by economists:

The goals of the EMS system are to prevent death, disability and suffering in persons with injury or acute illness. The allocation of public resources should be systematically directed to these ends; ideally, the EMS planner should be able to assess the impact of proposed combinations of money, people, facilities and equipment in terms of death, disability and suffering. In other words, the best planning requires input-output relationships linking resource allocations to patient outcomes.

Unfortunately, the input-output relationships referred to by Willemain are unavailable. Thus, this study will concentrate on the input side of EMS delivery while exploring the resource allocation problem in a theoretical framework. The empirical results hopefully will be useful to health

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planners and policy-makers who must deal with standards for EMS delivery and the costs associated with those standards. The theoretical framework is intended to provide insights into the EMS resource allocation process and the need for future research.

The *1974 State EMS Plan* [California Department of Health, 1974, p. 5] lists several specific goals, which will be used to provide boundaries for this study. Among the goals listed are the following:

To create an emergency medical services system consisting of an organized pattern of readiness and response services based on private and public agreements and areawide operational procedures, including:

- a) Contractual or direct public provision arrangements with certified emergency medical transportation services providing a 24-hour zoned deployment of sufficient numbers and types of vehicles and crews in relation to emergency medical facilities to meet the needs within the systems area.
- b) Policies and procedures ensuring that necessary emergency medical services will be rendered to all patients requiring such services without prior inquiry as to ability to pay.
- c) Programs of public education and information which take into account the needs of visitors, as well as residents of the area, to know or be able to learn immediately the means of obtaining emergency medical services....
- d) Assessment of the costs and benefits of alternative designs for the statewide system and recommendations for allocating available financial resources so as to ensure optimal system development and availability of quality service.

An operational interpretation of these objectives is needed. In terms of an economic model, the consumption and production aspects of EMS must be identified. Assumptions about the demand for EMS will be discussed as well as the production and distribution of EMS to satisfy the demand. Although

the state goals listed above are admirable, the costs associated with these goals have never been quantified. One objective of this study, therefore, is to quantify these costs.

Objectives of the Study

The specific intent of this study is to analyze EMS delivery in a rural environment. In 1974 California was divided into 12 regions for health planning purposes. One of these regions--Superior California--provides the rural environment needed for this study. The sparsely settled mountainous areas surrounding small population clusters in the foothills of the upper Sacramento Valley are typical of rural population distributions. The Superior California Comprehensive Health Planning Agency, currently known as a Health Systems Agency, provides health planning expertise to the region, and therefore represents an established administrative unit involved in the EMS planning process. Although the agency does not at present have a legal mandate to oversee the delivery of EMS, it may soon have the responsibility to approve or deny applications for the establishment of additional EMS facilities within the region. Hence, the planning body will then be concerned with all aspects of EMS in a rural area.

The goals quoted above emphasize that the provision of EMS should be based on need. The need for health care is defined by the medical profession; whereas the demand for health care is the translation of needs into the action of seeking medical services.

The state goals also emphasize that the provision of EMS should not be based on ability-to-pay--that is, price and income are not to influence

the rationing of EMS among consumers. Thus, the demand for EMS is assumed to be perfectly inelastic with respect to price and income in this study.

Due to the heavy influx of recreationists and transients into the study area, particular attention will be paid to quantification of seasonal population changes. The following quote is indicative of the problem [Area II Regional Medical Program, 1972, p. 4]:

An additional factor which serves to increase the pressure on over-taxed health facilities and services is the impact of the resort and recreation traffic. The presence of recreational facilities in mountain and lake areas attract tourists, campers, and visitors. More than six million persons visited 29 state parks in Northeastern California and 1,750,000 registered at 3 National Parks within the target area during 1969-70. Week-end populations may increase many fold during recreation seasons compounding the load on health care resources.

The deployment of EMS facilities refers to their size, number, and location. Size of facility is defined as the annual number of calls served by each facility. Since the "consumption" of EMS occurs at the point of production [Jeffers, *et al.*, 1971], availability (i.e. location) of EMS is crucial. The deployment analysis in this study uses a least-cost algorithm to find the size, number, and location of EMS facilities subject to a constraint that the demand for EMS be satisfied. As is the case in most location analyses, this study specifies that the demand for EMS and the potential EMS facility sites be located at discrete points.

Quality of service, of course, involves value judgments making quantification difficult, but the process is further complicated by the necessity of describing EMS delivery as a system of several components. Personnel training, transport equipment, and communication equipment are all part of the EMS system. When referring to quality, personnel training levels and equipment type should be specified. Some guidance to quality

specification is offered by state regulations such as those covering the training of drivers and attendants. For purposes of this analysis it is assumed that the level of training of medical personnel and the quality of the communication equipment is adequate for any spatial arrangement of EMS facilities. A further analysis might examine the trade-offs among training, communication equipment and facility location as reflected by the mortality and morbidity of patients entering the EMS system.

Goal (d) above is concerned with assessing the costs and benefits of alternative EMS system designs. The several EMS system designs analyzed in this study are under alternative time constraints placed on the location algorithm. Response time, or the time between the notification of an emergency and the arrival of an ambulance at the scene is often used as a measure of the effectiveness of an EMS system. This effectiveness measure assumes that time-to-treatment has an important effect upon morbidity and mortality. A response time of 10 to 30 minutes has been used as a standard in urban areas. In a rural area, however, response time may be over an hour. As would be expected, a very fast response time requires additional facilities or ambulances or both, which, of course, increase the cost of an EMS system. The optimal size, number, and location of EMS facilities will be found under various time constraints. As the time constraint is changed, the algorithm determines the total annual cost for the regional EMS system as well as the deployment zones or the demand points served by each EMS facility.

This study concentrates on the cost or production aspects of EMS. The reduction in death, disability, and suffering is a direct benefit of an

EMS system. From a societal viewpoint or for the resource allocation process, benefits from an EMS system must be weighed against costs. Unfortunately, the benefits or patient outcomes associated with EMS resource allocation decisions have been neither well-documented by the medical profession nor accurately quantified by economists. Furthermore, a problem arises when an EMS facility is established to serve a community which may not have the ability to pay for such a system. In more succinct terms; who pays the costs, and who receives the benefits?

This report first presents a framework for the analysis, giving an overview of the study area and the location model in Section II. The next two sections (III and IV) provide a detailed treatment of the production of and demand for emergency health services. Those who are interested mainly in the empirical results, may turn directly to Section V where the location patterns are presented under alternative time constraints. A discussion of the financial feasibility of emergency facilities is given in Section VI, followed by a brief summary of findings and suggestions for further work in Section VII.

II. FRAMEWORK OF ANALYSIS

General Considerations

A problem faced by a health planning agency is to provide emergency ambulance service to a given population. Two basic premises in this study are: (1) health services should be provided to all persons needing these services and (2) health services should be provided as efficiently (least-cost) as possible [Cordes, 1975]. Two standards of effectiveness used

throughout this study are response time and service time, where response time is time elapsed between the time a call is received and the arrival of the ambulance at the emergency scene, and service time is the time from the dispatch of the ambulance to the transfer of the patient to a hospital. The former standard emphasizes a rapid response of vehicle and trained crew to an individual in need of acute care; the latter, a rapid transport of the patient to a hospital emergency room.

The major objectives of this research are: (1) to minimize total costs of providing ambulance service under different standards of effectiveness, (2) to determine the trade-off between costs and standards of effectiveness, and (3) to analyze the financial feasibility of providing EMS as standards of effectiveness and facility usage change.

Operational Model

Economic literature on the location of firms and/or production is quite extensive. The theoretical work of Lefebvre [1958], Isard [1956], Kuenne [1963], and Takayama and Judge [1971] should be acknowledged as should a large number of applied studies (e.g., Weinschenck, *et al.*, [1969]). More recent work has concentrated on the location problems within the public sector (Miller and King [1971] and Reville, *et al.* [1970]).

As to solution procedures, a relatively new class of algorithms, known as tree-searching or combinatorial programming, can be applied to location problems which exhibit certain characteristics.^{1/} Typically, these problems

^{1/} These problems are sometimes called location-allocation problems. They have the following general structure (Scott [1970], p. 118): "Suppose that there are given (a) a set of n points distributed in the plane; (b) a numerical weight to be attached to each point; and (c) a set of m indivisible centroids without predetermined locations; then the location-allocation problem in its most general form is to find locations for the m centroids and an allocation of each point, or fraction of a point, to some centroid so as to optimize an objective function." In this study, m , the number of centroids or facilities, is also part of the solution rather than given.

minimize either assembly and processing or processing and distribution costs where supply or demand, respectively, is predetermined. These models can be used for locating commodity processing facilities, warehouses, hospitals, clinics, schools, airports, transport terminals, police stations, or fire stations (e.g., Chaiken and Larson [1972]). If the processing facility's total cost function is linear with a positive intercept, the problem becomes the classic fixed charges transportation problem (Hadley [1962], p. 136; Scott [1970], p. 128). Such a function implies declining average facility cost.

Additional constraints (such as travel time or distance) are often added to these models to meet various goals defined by a planning body concerned with the provisions of the particular good or service. Such a system of facilities, however, may not be economically self-supporting solely by user fees. The reader is referred to Hirsch [1970] for a comprehensive discussion of demand and supply aspects of publicly provided goods and services.

Algorithms used to solve location problems range from complete enumeration, such as the Stollsteimer [1963] model, to the more systematic examination of a combinatorial tree.^{1/} The latter approach includes the branch and bound algorithm, backtrack programming and discrete dynamic programming (see Scott [1970] Ch. 2 for an introduction to these techniques). Manne [1964] utilized dynamic programming to solve the location-allocation problem "based on the fact that the total cost of processing

^{1/} Integer programming is another alternative but its application seems limited to small, well-behaved problems.

and distribution form a hypercube with regard to all possible combinations of locations" (Weinschenck, *et al.*, [1969], p. 47). This technique is also known as "steepest ascent one point move algorithm," or SAOPMA. Manne notes, however, that the algorithm may give a local rather than a global optimum. An example of backtrack programming used as a location algorithm is not known; however, the solution technique is similar to that of branch and bound programming utilized in this study. All of these techniques can solve very general location problems including those with some nonlinearities. Their major drawback has been the inability to handle large problems, either because of computer storage requirements or solution times.^{1/}

This study utilizes a modified branch and bound algorithm to solve the fixed-charges transportation problem noted above. The algorithm was proposed by Efroymson and Ray [1966]. Khumawala [1970, 1972] improved the efficiency of the original algorithm. On the CDC 7600 computer, located at the Lawrence Laboratory, Berkeley, California, this algorithm was found to be operational for moderately large location problems. (Extensive testing of the capacity and time requirements of the algorithm is reported by Khumawala, [1970]). The basic idea is to solve a sequence of linear programming problems (not necessarily meeting the integer restriction) that give progressively improved lower bounds on the value of the objective function of the mixed integer programming problem. The algorithm terminates

^{1/} Another category of solution algorithms, not discussed here, are known as heuristic methods and defined as (Scott, [1970], p. 39): "... algorithms [which] represent sets of rules which produce solutions to given problems, but which do not necessarily produce the best possible solutions."

when the lowest value for an integer solution is reached. The mathematical model is as follows:

$$\text{Minimize } Z = \sum_{i \in N_j} \sum_{j=1}^n C_{ij} X_{ij} + \sum_{i=1}^m f_i y_i \quad (1)$$

$$\text{Subject to: } \sum_{i \in N_j} X_{ij} = 1 \quad j = 1, 2, \dots, n \quad (2)$$

$$0 \leq \sum_{j \in P_i} X_{ij} \leq n_i y_i \quad i = 1, 2, \dots, m \quad (3)$$

$$y_i = 0, 1 \quad i = 1, 2, \dots, m \quad (4)$$

where:

C_{ij} = total cost of satisfying the entire demand for EMS services
at demand point j from facility i

$C_{ij} = (t_{ij} + \lambda_i) D_j$

t_{ij} = (\$ cost per patient per mile) (miles from i to j)

λ_i = cost per patient which is independent of distance (e.g., linen
supplies, equipment use, etc.)

D_j = demand for EMS (ambulance service) at demand point j (patients)

X_{ij} = the fraction of the demand at point j which is met by a facility
at i

f_i = fixed charge for establishing and maintaining a facility at i

y_i = 1 if a facility is established at i ; 0 if not

n = total number of demand points

m = total number of potential EMS facility sites

P_i = the set of demand points which can be served by a facility at i

- n_i = the number of demand points which can be served by a facility at i
 N_j = the set of EMS facilities which can serve demand point j .

The objective function (equation 1) indicates the mixed integer programming nature of the problem since X_j is continuous and y_i is a binary variable. Equation 2 ensures that total demand at each demand point is exactly satisfied, while equation 3 ensures that a facility i is open before it can serve demand point j .

III. PRODUCTION OF EMERGENCY HEALTH SERVICES

Legislative Perspective

Several factors are responsible for generating interest recently in EMS as an important component of health care planning. In the context of rapidly rising prices of medical care in general, attention has been drawn to the extreme costliness of emergency medical care. Furthermore, emergency medical care is an unevenly distributed service, for many geographical areas have acute medical manpower shortages [Matthews, 1973]. It is particularly in rural areas where emergency facility services are deficient. Another factor focusing attention on EMS is that its use as an entry point into the health care system seems to be growing at a disproportionate rate. There has even been an increased use of EMS for other than true emergencies.

As the awareness of EMS problems increased, several government agencies have become involved, and since the mid-1960's several pieces of legislation have significantly affected EMS. The 1966 Traffic Safety Act charged the National Traffic Safety Administration with making highways safer. One

outcome was the development of standards for emergency care systems by the U.S. Department of Transportation. In California it is the Office of Traffic Safety that coordinates EMS for the Department of Transportation.

Government units most concerned with emergency medical care are the various health agencies. At the federal level, the U.S. Department of Health, Education, and Welfare (HEW) has responsibility for emergency care via the Health Services and Mental Health Administration. The California State Department of Health has the Bureau of Emergency Medical Services to facilitate planning and coordination procedures as well as set goals and standards for the state EMS plan. Comprehensive Health Planning (CHP) agencies (currently called Health Systems Agencies or HSA's) are perhaps the most significant local bodies engaged in emergency health care planning. CHP agencies were created under the Partnership for Health Act in 1967; HSA's were created under the National Planning and Resource Development Act of 1974. These agencies have the responsibility and power to approve or deny various additions or deletions to the current medical care system within their jurisdiction. They also attempt to coordinate planning of the diverse interests within the medical care industry. The most EMS-specific legislation is the Emergency Medical Services Systems Development Act of 1973 which at the federal level is carried out by HEW. The Act is designed to foster EMS demonstration projects throughout the U.S., with particular regard for rural areas.

Characteristics of EMS in Rural Areas

In 1968, the National Highway Safety Bureau released a study by Dunlop and Associates [1968] entitled *Economics of Highway Emergency*

Ambulance Services, which was one of the most comprehensive studies of ambulance services in the U.S. The report undertook two tasks [p. 9]: "(1) to describe the present status of emergency ambulance service across the country, their problems and their ability to continue to provide emergency services, and (2) to develop methods and guideline information helpful to individuals at all levels of government in planning new or expanded services." Types of ambulance purveyors were identified by their principal source of revenue. Commercial or private purveyors are supported by the users of the ambulance system; municipal or county units may be wholly or partially supported by taxes; volunteer groups are dependent upon donations of time, equipment, supplies, and monies. Funeral home-sponsored ambulances and volunteer groups are the most common in the nation's rural areas. The prevalence of volunteer services in rural areas appears to be a direct result of low aggregate demand for emergency medical services and the high costs of providing quality emergency care comparable to that of urban areas. Sparsely populated areas not only generate fewer calls but increased distances lead to less effective service. The Dunlop report indicated that 80 percent of the ambulance services had less than 500 calls per year. The report further notes the high cost of high-quality (24 hours per day) emergency care: annual costs per ambulance in 1968 were estimated to be between \$60,000 and \$65,000. Much of this (50-90 percent) is fixed cost with personnel accounting for 60 percent of the fixed cost and housing and depreciation, most of the remainder. Personnel training and recruitment are of major concern to emergency care purveyors. Training standards for emergency medical care personnel are currently undergoing revision, with the

likely result that more schooling will be required (see the 1974 California EMS plan). In addition, the ambulance industry has traditionally paid only minimum wages to drivers and attendants; as a consequence, recruitment and rapid personnel turnover are problems. Revenue collection is another area of concern with delinquent or tardy payments by individuals and institutions (welfare and insurance agencies) apparently a common occurrence. Areas with a large transient population during all or parts of the year tend to have more noncollections. The seasonal demand for emergency medical care also tends to strain a system designed to accommodate only resident needs.

The public's lack of awareness of proper usage of an emergency care system also causes concern and adds to costs. When calls are made for non-urgent causes, resources are diverted from their best use, increasing the cost of the system.

In rural areas where private emergency medical care purveyors do operate and also in several urban areas, they frequently ask for a restraint on competition in order to ensure a stable demand. Thus, local governments have resorted to exclusive contracts, zoning, regulated monopolies, franchising, or outright subsidies to guarantee that emergency service will be present for their constituents.

EMS Production Activities

Table 1 presents an abstraction of a basic EMS unit, combining labor, equipment, and facilities to produce ambulance calls. These inputs are used to perform a variety of tasks, such as transportation, communication, medical care and clerical work. The allocation of functions varies among

TABLE 1--Typical Allocations of Functions Among the Elements of
an Ambulance Service System

System elements	System Functions			
	Transportation	Medical care	Communications	Records & support
Labor	Drivers	Attendants	Dispatchers	Clerks
Equipment	Ambulances		Radios, phones, teletypes, etc.	Office & data reduction equipment
Facilities	Garages, workshops		Dispatch center	Offices, bunkhouses, etc.

Source: Dunlop and Associates, Inc. [1968]

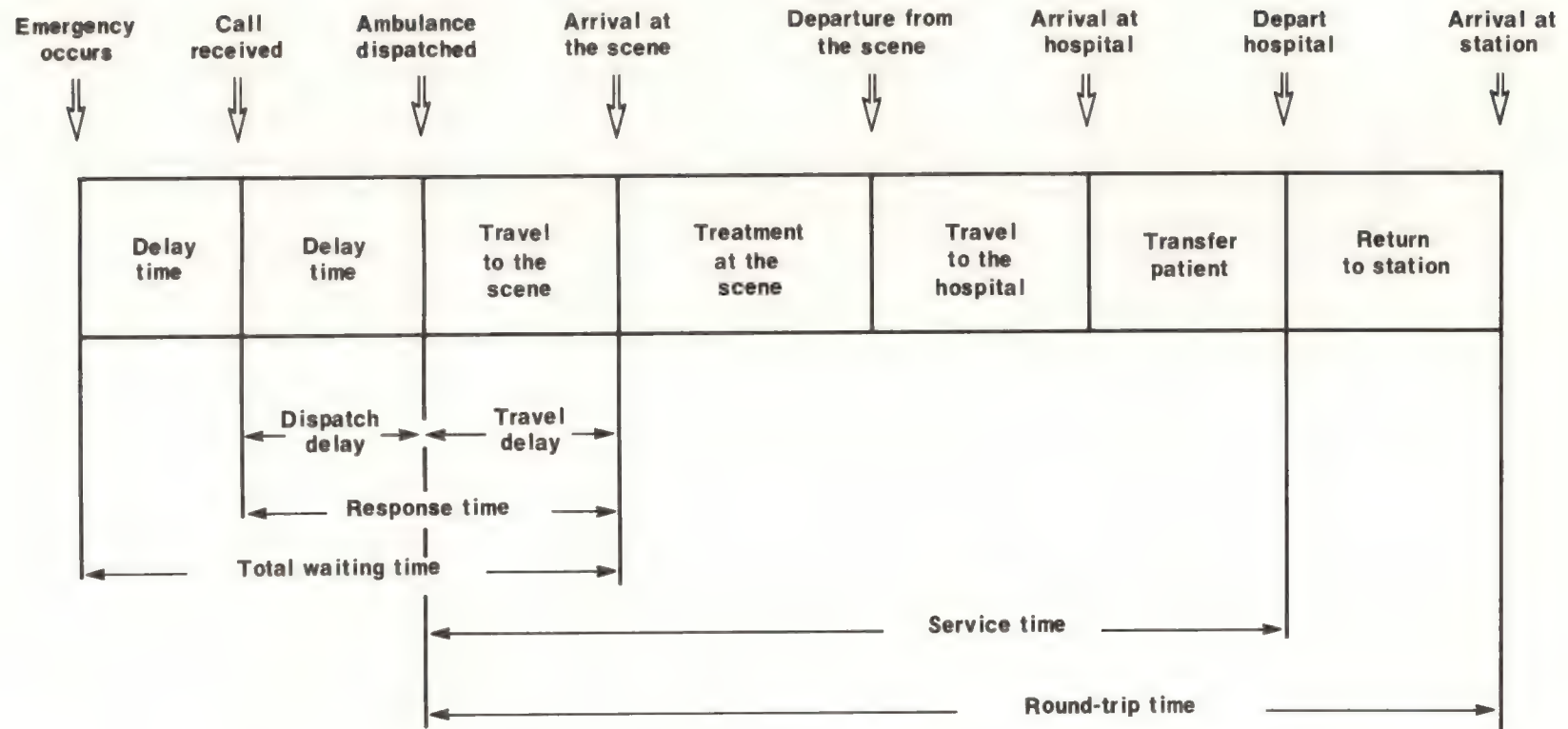
the elements of the system, but basically management specifies policies and procedures that define the functions and interactions of the system elements.

The emphasis of this study is on the transportation function of an EMS system and, in particular, the time of response of the system. In order to analyze the transport function in isolation, the remaining functions, particularly the medical care and communications functions, are specified at certain levels of quality. As formulated, the analysis (size, number, and location of facilities) is performed under the assumption that the level of training of the medical personnel and the quality of communication is adequate for any spatial arrangement of EMS facilities. The specification of the level of training of the medical personnel and the quantity and cost of the communication equipment assumed for any EMS facility proposed in this analysis is given in Appendix A.

The dynamics of EMS, pertaining to the transportation function, is illustrated in Figure 1. The traditional view in the medical profession is that total waiting should be minimized [Waller, *et al.*, 1964]. For this reason, the health planner imposes standards on total waiting time, minimizing time after the call is received (i.e., minimizing response time). The following passage from the 1975 *California State Plan for Emergency Medical Services* (p. 132) exemplifies this goal:

In emergency situations, time is a crucial factor for securing assistance, to protect the patient from further preventable deterioration, and to promote optimum clinical disposition. A maximum response time pattern is critical in determining whether adequate assistance for medical emergencies can be achieved.

Figure 1 Sequence of Events Following an Emergency



Source: Stevenson (1974)

The maximum response time for transport should be met for 95 percent of the requests occurring in that ambulance service area. Maximum response time may vary with population density levels as shown below:

<u>Density</u>	<u>Maximum Response Time</u>
High	10 minutes or less
Medium	20 minutes or less
Low	30 minutes or less

Service time also may be used as a criterion or standard. Particularly in rural areas where medical training of ambulance personnel may be minimal, it is crucial that the time between ambulance dispatch and patient transfer to a hospital be minimized.

To place the emphasis on response time in perspective, mention should be made of other research that has suggested alternative goals. Herlihy [1973] concluded that in rural areas an adequate communication system would yield a greater marginal return than would reduced response time, because a significant number of patients have to wait to receive medical attention after being transported to a hospital. Plaas *et al.* [1974 p. 17] note the lag between the occurrence of an emergency and detection time, and make the following observation:

...the response time of an ambulance to the scene may not be of critical importance. Indeed, if there is an hour's delay between when the incident occurs and when a call for help is made, and by some innovation response time is reduced from 30 minutes to 20 minutes, then the actual reduction from the time of the incident to the time of the first professional care is not 33 percent but 11 percent. It may thus be more useful to investigate whether some investment in remote area communications is more beneficial than an investment in more ambulances.

Nevertheless, for the analysis here, response and service time will be considered critical to the allocation of health resources.

Theoretical Cost Functions

The firm producing EMS faces a relationship between the inputs or factors of production and the resulting output measured in terms of ambulance calls. This relationship (i.e., the production function) and the cost conditions affecting the inputs determine the firm's cost function. For this study, the distinction between long-run and short-run cost functions is of interest. As typically defined, the long run implies that all factors are variable; while in the short-run plant size is assumed constant. The long-run cost function is defined to be associated with the lowest cost of production for plants of differing size. Logan [1962 p. 12] refers to the long-run cost function as an economies of scale curve and describes that function as follows:

The economies of scale curve, then, is simply the locus of costs "expected from the operations of plants of various sizes, *when operations are organized as efficiently as possible under the given conditions.*"^{1/} Such a cost function has a variety of uses with the prime value to the firm being one of showing the expected relative operating cost of one size of plant against the cost of another size. The cost function then becomes a planning device for the producer in determining the size of a prospective new plant.

The usefulness of a long-run cost function is in terms of its planning properties, for it allows the firm to analyze a variety of plant sizes and determine which size of plant is appropriate for the expected future demand.

A long-run average cost function which slopes downward and to the right exhibits economies of scale. Reasons given for economies of scale include

^{1/} Bressler, R. G., Jr., "Research Determination of Economies of Scale," *Journal of Farm Economics*, XXVIII (August 1945), p. 526.

technical forces, management, marketing economies, etc. The most obvious reason for economies of scale in the production of EMS is the large "fixed" cost relative to the variable costs as well as the indivisibilities of certain inputs such as ambulance vehicles. "Certain equipment may not be 'economically available' to smaller plants, since its operation would be at considerably less than its capacity" [Logan, p. 19].

The use of the term "fixed" costs in the last paragraph may seem inconsistent with the long-run concept, but the inclusion of a long-run "fixed" cost represents "the minimum average annual long-run cost of establishing and maintaining a plant" [Stollsteimer, 1962, p. 636]---or, as French, *et al.*, [1956, p. 572] state:

...the fixed base represents the long-run average rate of returns above variable costs that are required to maintain and replace the capital goods. Returns in any particular short-run period need not cover these costs, but over the long run they must average this amount if the firm is to continue in business.

Throughout this study, each EMS facility is assumed to have a long-run total cost function, which is linear with a positive intercept. Figure 2 illustrates this form. The LRTC is an "envelope" curve to the linear short-run total cost curves ($SRTC_I$). Cost curves $SRTC_I$, $SRTC_{II}$, and $SRTC_{III}$ reach a technical capacity constraint at q_1 , q_2 , and q_3 , respectively. The right-hand side of Figure 2 shows the companion long- and short-run average cost curves. The LRTC curve is drawn here to coincide with $SRTC$ curve of the smallest plant. The analytical framework to be presented later requires this assumption.

A final aspect of EMS facility cost functions deals with the concept of discontinuities. Logan [1962 p. 35] discusses this point as follows:

While short- and long-run cost functions are generally represented by continuous curves, in reality cost functions often exhibit discontinuities. Such discontinuities generally result from indivisibilities of factors of production. In other words, inputs are added by discrete units instead of as a continuous flow.

Cost functions of EMS facilities tend to exhibit such discontinuities. The most severe example of indivisibility arises when an additional ambulance must be added to a facility. Figure 3 illustrates a total cost step function where an ambulance is added at various intervals. Thus the long-run total cost curve may take on a "jagged" appearance because of these discontinuities [Logan, p. 39]. The long-run total cost curve used in the analysis approximates this "jagged" function in a linear fashion as shown in Figure 3.

Empirical Cost Function

Dunlop [1968] presents one way--queueing theory--of approximating the total cost step function alluded to above. (See Plaas, *et al.*, Vol. I, [1974] for an annotated bibliography of other queueing methods.) By assuming a Poisson distribution for the arrival rate of ambulance calls for a given service time and by requiring that at least one ambulance be available at least 90 percent of the time when a call arrives, Dunlop is able to show how many calls per year a one-ambulance and a two-ambulance system can serve. Figure 4 shows the theoretical step function derived from the Dunlop model if service times of one and one-half hour and one-half hour are assumed for one- and two-ambulance systems. A one-ambulance system

Figure 2 Hypothetical Short and Long Run Cost Curves for Firms of Different Capacities

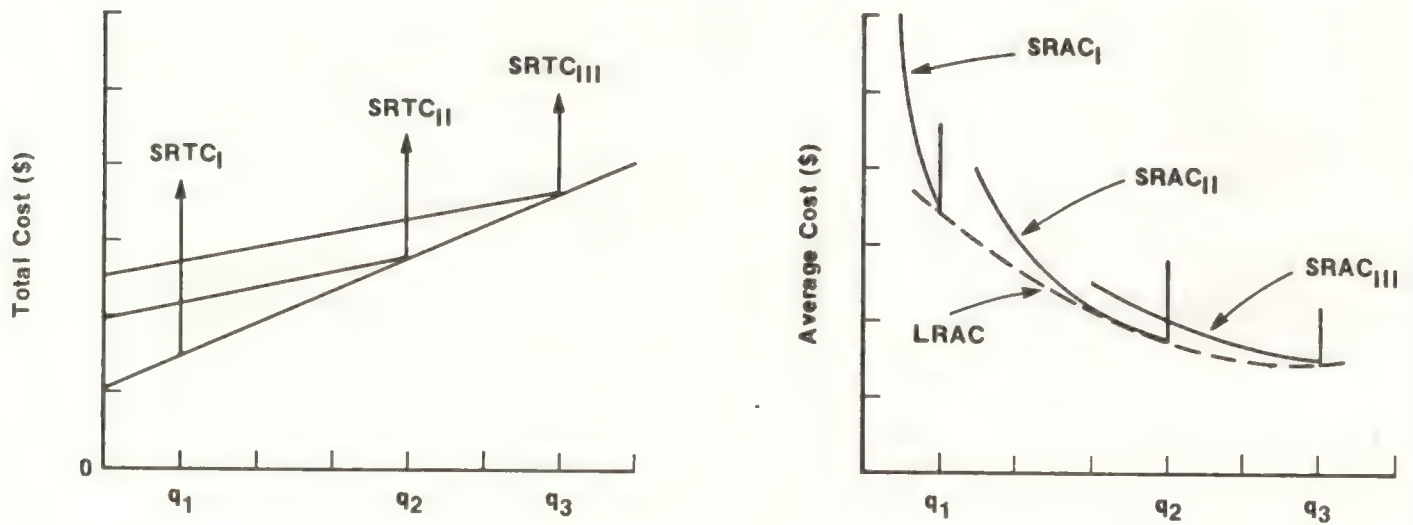


Figure 3 Discontinuities Associated with Adding Numbers of Ambulances for Firms I and II

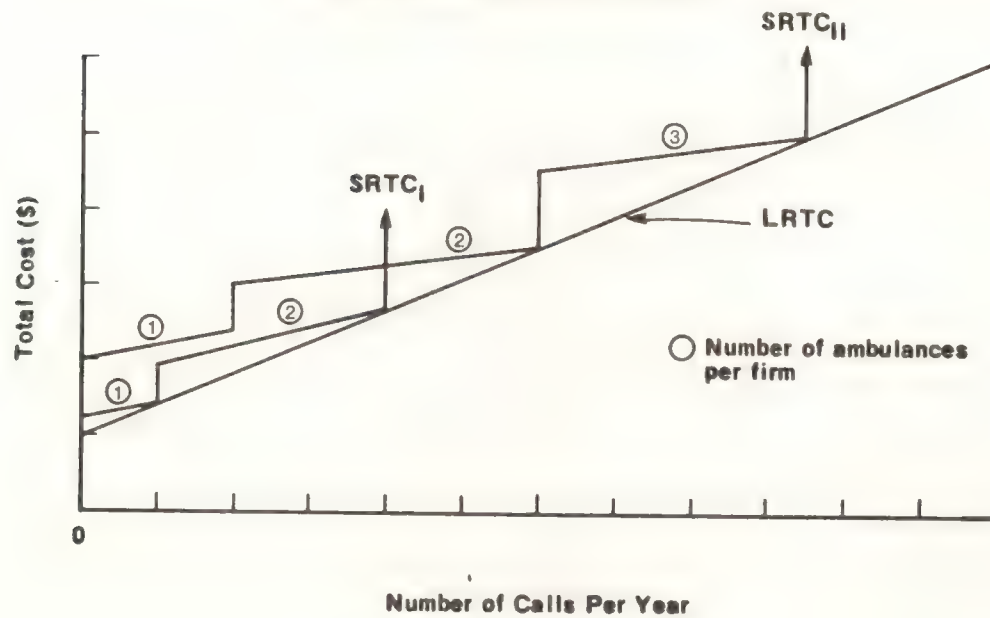
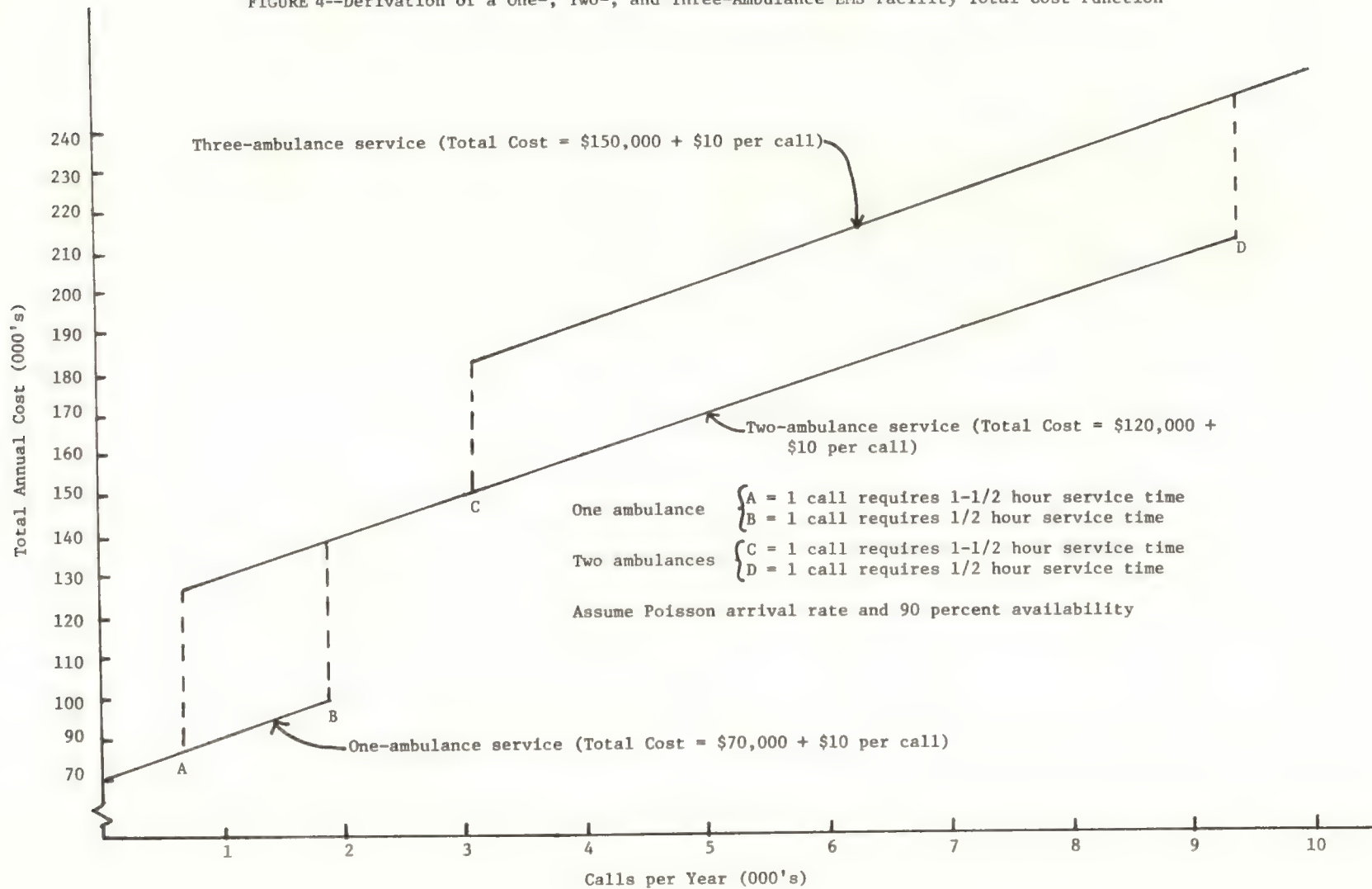


FIGURE 4--Derivation of a One-, Two-, and Three-Ambulance EMS Facility Total Cost Function



can handle between 613 and 1,927 calls per year depending on length of service time. A two-ambulance system is able to serve between 3,066 and 9,417 calls per year also depending on the service time.

Some data are available which indicate the actual, rather than theoretical, number of calls per ambulance per year. Table 2 indirectly reflects at least four factors influencing the number of calls per year per ambulance: the area demand for ambulance service, variation in service time, type of service, and number of ambulances per service. A shorter service time, characteristic of a more densely settled area, enables both a one- and two-ambulance system to serve more calls per year. Terrain, climatic conditions, type of roads, and distance to a hospital all influence service time and thus could cause wide variation among ambulance operators which otherwise are similar. Data are not available to distinguish between one, two, three, or more ambulance systems. Therefore, the data in Table 2 are average indications of the actual number of calls per ambulance. *The Ambulance Survey* [Dunlop, 1968, p. 128] notes that "In the 'rural' counties, 86 percent of the services averaged less than 50 calls per month." The implication is that many ambulance services have a large amount of excess capacity (or insufficient demand relative to resources available), at least compared to the queueing model results presented above. For example, the volunteer fire departments which are typically found in rural areas, had an average of 102.3 calls per ambulance in 1969 while the commercial operators, which are often in urban areas, averaged 805.3 calls per ambulance in the same year.

TABLE 2--Number of Operators, Trips per Operator, Ambulances per Operator and Trips per Ambulance by Type of Ambulance Service, California, 1969

Type of service	Operators	Ambulances per operator	Trips per operator	Trips per ambulance
		number		
Commercial	177	2.4	2,738	805.3
Funeral director	36	3.4	906	266.5
Private or nonprofit hospital	8	1.9	434	228.4
Local tax supported hospital	13	4.1	3,838	936.1
Volunteer fire department	25	1.3	133	102.3
Municipal, district or other fire department	37	1.8	811	455.5
Police department	7	3.4	3,714	1,092.4
Voluntary organizations or other local government services	14	4.1	7,975	1,945.1
Total	331	2.98	2,245	547

Source: 1968 *Ambulance Survey*. [California Department of Transportation, 1970]

Since the location model used in this study is essentially a planning device, the potential EMS facilities were assumed uncapacitated,^{1/} which necessitated the estimation of a long-run total cost function. Output of an EMS facility is measured in terms of ambulance calls per unit of time. The long-run total cost function for an EMS facility was estimated to be a linear function with a positive intercept. The intercept was interpreted as the long-run cost of establishing and maintaining a facility. The annual fixed cost of a 24-hour per day, 365 days per year EMS (one ambulance) service, manned with adequately trained crews and supporting clerical staff, and stocked with appropriate communication and transport equipment was estimated to be \$70,000 (see Appendix A).^{2/} The estimates were derived from an update of the Dunlop study as well as data from the California Ambulance Association (personal interview, 1975). The aggregate variable cost of linens, bandages, ambulance maintenance, etc., was estimated at \$10 per call. The over-the-road cost of ambulance vehicles (gas, oil, tires, etc.) was estimated at \$0.10 per mile per patient. Although the algorithm is designed to handle facility costs (fixed) which may vary by

^{1/} Facilities were not limited in the number of calls each could serve per year.

^{2/} This model implicitly assumes an ambulance will always be available at a potential facility, thereby neglecting probabilistic aspects of ambulance call arrival rates and ambulance service times. Using queueing theory notation, this implies an M/M/∞ or M/G/∞ system (Wagner, p. 865-866). Thus the facilities are commonly assumed to be uncapacitated and a post optimization analysis determines the number of ambulances necessary at each facility to keep expected (in a statistical sense) response time below a given standard. (See Bell and Allen [1969] for a discussion of the number of ambulances necessary at a given location.) An M/G/∞ queueing model, for a one-ambulance facility servicing 2,012 calls per year (the largest number reported in this study), using a mean monthly arrival rate and having a one-hour average service time would exhibit a probability of 0.19 for a call having to wait.

location, there is little justification for doing so; it was assumed, therefore, that the fixed facility costs were equal at all potential facility sites.

IV. DEMAND FOR EMERGENCY HEALTH SERVICES

Theoretical Aspects

Economists typically hypothesize that the quantity demanded for a particular good or service is a function of several variables including the price of the good or service, the price of other goods and services, income and/or financial reserves, and the collective preferences of the population. Furthermore, the number and location of people influence the spatial intensity of demand for goods and services in a particular area.

When considering medical care, health planners, health agencies, and health professionals tend to use the word "need" rather than demand. Jeffers, *et al.* [1971, p. 46] use the following definition of need:

That quantity of medical services which expert medical opinion believes ought to be consumed over a relevant time period in order for its members to remain or become as "healthy" as is permitted by existing medical knowledge.

The definition of need says nothing about the "restraining" variables noted in the demand function. Hence, there is a gap between need estimates and the actual consumption of a good or service. Not only are the restraining variables of price (including the extent of insurance coverage), income, tastes, and preferences responsible for this gap, but also consumer ignorance, inertia, fear of pain, and other psychological barriers to medical care consumption. For purposes of this study, the demand rather than need

concept is utilized. This approach is pragmatic because of: (1) the difficulty of the medical profession in establishing an adequate measure of need, (2) the obvious discrepancy between need standards^{1/} and actual consumption by the population under consideration, and (3) the fact that available data measure only the actual usage or consumption of medical services.

The demand for EMS is conceptually less complex than for all medical services.^{2/} In a true life threatening situation in which medical attention is not postponable, the influence of prices or ability-to-pay diminishes. The influence of prices and ability-to-pay upon the consumption of emergency ambulance service is, therefore, hypothesized to be minimal. Population size and consumer preferences then become the dominant determinants of demand.^{3/}

From the definition of EMS used in the *California State Plan for Emergency Medical Services* (1974, p. 2), it is seen that the consumption of EMS is really the consumption of several interrelated elements:

Emergency Medical Services (EMS) are those communications, transportation, medical and related services rendered in response to the perceived individual need for immediate medical care in order to ameliorate or prevent suffering and disability and reduce the incidence of death.

^{1/} See Daberkow [1976] for attempts to evaluate various need indicators for EMS in the study area.

^{2/} Daberkow [1976] presents a review of health care demand models in general.

^{3/} A number of other variables have been suggested to impact aggregate EMS demand including age distribution, education, health insurance coverage, type of employment, health status and various socioeconomic characteristics of the population as well as the availability of ambulance services (i.e., supply) and alternative medical care resources (i.e. doctors and proximity to hospitals). See Daberkow (1976, Ch. 5).

The service of an ambulance provider embodies most of these functions. The ambulance provider usually serves as a communication link between the ambulance and hospital as well as between the ambulance and accident site. The ambulance provider also is involved in the transport of victims from the accident site or demand point to the nearest medical facility, usually a hospital. The ambulance driver and attendant can legally provide only limited medical attention to stabilize the patient's condition.

The *State Plan for Emergency Medical Services* [1974, p. 2] also defines a medical emergency:

A medical emergency is a situation in which there is a perceived physiological need for immediate medical care, based on an injury or other unforeseen acute physical or mental disorder which apparently threatens life or function. It is recognized that many of the patients using emergency rooms and departments do not fall within this definition. The resolution to this problem is through triage (sorting according to the apparent urgency of the need presented), which is essentially a clinical determination and must be made by a qualified individual.

The assumption throughout this study will be that each medical emergency generates a need for emergency medical service. The question arises as to whether this need is translated into demand for EMS. The definition of a medical emergency, given above, recognizes that not all perceived medical emergencies are life-threatening. Hence hospital emergency rooms receive patients who do not have a clinical life-threatening emergency but only a self-perceived emergency. It has also been suggested that the hospital emergency room is sometimes used as an entry point into the medical system. This is particularly true of travelers, new residents, and transient workers who are unfamiliar with the location of physicians or other medical personnel in the area.

The demand for emergency care can be separated into two categories: (1) the demand for emergency room services and (2) the demand for ambulance services. The latter requires that some form of communication and transport be performed, whereas the former requires only medical attention. Demand for ambulance services implies a life-threatening situation in most instances, with the exception of routine transfers.

Emergency ambulance calls are generated from two basic causes: (1) accidents and (2) acute illnesses. Several studies have attempted to disaggregate these two categories (Table 3). These studies (Waller, *et al* [1966], Aldrich [1971], and Deems [1973]) show the variety of circumstances in which ambulances are used and indicate differing relative frequencies of specific emergency situations among areas of the U.S.^{1/} The studies use different classification schemes, but some generalizations about accidents seem appropriate. Traffic accidents account for nearly one-third of the calls in the first two studies and 10 percent in the remaining study. All accidents (traffic plus other) include nearly one-half of all calls in the first two studies but only 30 percent in the remaining study; the remainder of calls in each study were primarily for illnesses.

EMS Utilization in the Study Area

Data on EMS utilization for the study area are taken from three sources: (1) *1972 Regional Medical Program Survey* [Superior California

^{1/} Dry runs are not included in the Waller *et al* [1966] study.

TABLE 3--Distribution of Ambulance Calls by Medical
Diagnosis for Three StudiesThe Waller Yolo County, California Study

<u>Diagnosis</u>	<u>Percent of total calls</u>
Cardiovascular & respiratory disease	20.1
Traffic accidents	33.1
Other accidents	13.1
Poisoning and suicide	1.6
Acute & chronic alcoholism	3.7
Psychiatric	2.0
Acute abdomen	4.0
Obstetrical	1.1
Other	8.0
Unknown	<u>12.5</u>
Total	100.0

The Aldrich Los Angeles, California Study

<u>Diagnosis</u>	<u>Percent of total calls</u>
Auto accidents	26.6
Other accidents	21.0
Cardiac	4.9
Poisoning	3.5
Other illness	34.3
Dry runs	<u>9.9</u>
Total	100.0

The Deems Atlanta, Georgia Study

<u>Diagnosis</u>	<u>Percent of total calls</u>
Drug intoxication	7.1
Obstetric	3.7
Auto-related trauma	9.1
Other trauma	24.0
Cardiovascular	10.2
Other medical	20.6
Dry runs	<u>25.3</u>
Total	100.0

Source: Waller et. al. study [1966]; Aldrich et. al. study [1971]; Deems study [1973].

Comprehensive Health Planning Agency, 1974]; (2) *1975 California State Plan for EMS* [California Dept. of Health 1975]; and (3) *1968 Ambulance Survey* [California Department of Transportation 1970]. These data reflect utilization by residents as well as non-residents who are passing through the area (transients) as well as those who are visiting the recreation sites in the area. The following section relates total EMS usage to the resident population of the area while the subsequent section addresses the problem of seasonal fluctuations in the area's population.

Total emergency room arrivals, true emergencies, arrivals and emergencies per 1,000 residents, percent of true emergencies by selected categories, number of arrivals by ambulance and number of arrivals by auto for hospitals in the study area during 1972 are shown in Table 4. It should be stressed that much of these data are estimates by hospital personnel and therefore are subject to vagaries associated with lack of recall and inadequate, incomplete, or nonexistent records.

As would be expected, total emergency room arrivals are highest for the two most populous counties--Butte and Shasta. The resident per capita emergency room arrival ratio is quite varied among the hospital service areas, ranging from 345.9 arrivals per 1,000 residents in the Oroville hospital service area to 93.6 arrivals per 1,000 residents in the Gridley hospital service area. Emergency room arrivals can be divided into two groups by qualified medical personnel: those patients with true emergencies and those in need of only primary care. The percentage of total arrivals which were considered true emergencies by hospital personnel ranged from 100 percent at the Biggs-Gridley and Butte County hospitals to

TABLE 4--Emergency Room Arrivals, True Emergencies, Percent of True Emergencies by Selected Categories, Arrivals by Ambulance and Arrivals by Auto for Hospitals in the Study Area, 1972

County and Hospital	Total emergency room arrivals	H.S.A. ^{a/} arrivals per 1,000 residents	True emergencies		H.S.A. emergencies per 1,000 residents	Pct. true emergencies by selected causes			County emergency room arrivals				County Ambulance arrivals per 1,000 residents
			Percent of total arrivals	Number		Auto	Trauma	Heart	Percent by Auto	Number	Percent by Ambulance	Number	
	number	number	percent	number	number	percent			percent	number	percent	number	number
<u>Butte County</u>	<u>b/</u>	---	---	---	---	---	---	---	83	21,546	16	4,153	37.75
Chico Community Memorial Hospital (Chico H.S.A.)	5,100	223.8	55	2,805	105.0	10	25	10					
N.T. Enlow Hospital	5,956		40	2,382		25	45	5					
Feather River Hospital (Paradise H.S.A.)	3,150	198.1	15	473	29.7	<u>b/</u>	---	---					
Biggs-Gridley Memorial Hospital (Gridley H.S.A.)	1,376	93.6	100	1,376	93.6	25	65	5					
Butte County Community Hospital (Oroville H.S.A.)	1,463	345.9	100	1,463	120.0	0	26	0					
Medical Center Hospital	8,914		24	2,139		60	0	24					
<u>Glenn County</u>									60	2,063	40	1,375	88.7
Glenn General Hospital (Willows H.S.A.)	3,438	221.8	40	1,375	88.7	20	30	20					
<u>Shasta County</u>	---	---	---	---	---	---	---	---	83	21,707	15	4,008	50.8
Memorial Hospital	6,236	---	60	3,742	---	15	40	10					
Shasta General Hospital (Redding H.S.A.)	---	337.0	---	---	177.2	---	---	---					
Mercy Hospital	18,000	---	50	9,000	---	20	35	30					
Mayers Memorial Hospital (Fall River Mills H.S.A.)	1,971	281.6	26	512	73.1	60	20	10					
<u>Tehama County</u>									85	4,547	14	752	25.5
Corning Memorial Hospital (Corning H.S.A.)	1,466	178.8	75	1,100	134.1	5	49	2					
St. Elizabeth Community Hospital (Red Bluff H.S.A.)	3,884	182.3	52	2,000	93.9	5	31	2					
<u>Trinity County</u>									---	---	---	---	---
Trinity General Hospital (Weaverville H.S.A.)	1,220	162.7	50	610	81.3	---	---	---					

Source: Superior California Comprehensive Health Planning Association, [1974]

^{a/} Hospital Service Area

^{b/} Dashes indicate data not reported

a low of 15 percent at Paradise. The per capita true emergency arrivals is highest at the Redding hospital service area (177.2) and lowest at the Gridley hospital service area (29.7). Traffic accidents account for 60 percent of the true emergencies at the Oroville Medical Center and Fall River Mills hospitals. Over 60 percent of the true emergencies were from trauma cases at Biggs-Gridley hospital. Heart cases accounted for up to 30 percent of true emergencies in the study area hospitals.

Most arrivals at hospital emergency rooms are by private automobile. Ambulance arrivals range from 14 percent of total arrivals in Tehama County to a high of 40 percent in Glenn County. The fact that the majority of emergency room arrivals use automobiles has implications for the ambulance system in the study area. Without knowing the state average percentage of private auto emergency room arrivals, comments about the study area are speculative. If the study area has an unusually large percentage of emergency room patients who arrive by auto, it may be that EMS resources are inadequate, the public is unaware of ambulance availability, or perhaps a majority of emergency room patients do not require or are assumed not to require ambulance transport. One should also recall that the Table 4 data represent estimates for 1972 only, and information on the variation in these data are not available.

One source of EMS usage data over several years is available. The California Department of Health [1974] has collected data on hospital emergency room visits for 1971, 1972, and 1973 (see Table 5). The report, however, notes that the data come from several sources and, therefore, are not uniform across all hospitals. Of special concern is the possible

TABLE 5--Number of Emergency Room Visits to Study Area Hospitals
for 1971, 1972, and 1973

County and Hospital	Visits in Year			Visits per 1,000 H.S.A. ^{a/} residents, 1972
	1971	1972	1973	
	numbers in 1,000's			No.
Butte County				
N.T. Enloe Memorial Hospital (Chico H.S.A.)	5.2	6.3	10.4	234.8 ^{b/}
Chico Community Hospital	2.2	5.3	8.6	
Feather River Hospital (Paradise H.S.A.)	1.7	2.2	3.5	138.4
Biggs-Gridley Memorial Hospital (Gridley H.S.A.)	4.0	3.9	4.4	265.3
Medical Center Hospital of Oroville (Oroville H.S.A.)	8.9	10.0	16.0	333.3
Glen County				
Glenn General Hospital (Willows H.S.A.)	3.2	3.4	5.5	219.4
Shasta County				
Mayers Memorial Hospital (Fall River Mills H.S.A.)	1.3	0.5	0.9	71.4
Shasta General Hospital	4.8	0.5	0.2	287.9 ^{c/}
Mercy Hospital (Redding H.S.A.)	12.8	18.6	20.1	
Memorial Hospital	--	1.6	7.7	
Tehama County				
Corning Memorial Hospital (Corning H.S.A.)	--	1.5	2.0	182.9
St. Elizabeth Community Hospital (Red Bluff H.S.A.)	--	3.5	5.1	164.3
Trinity County				
Trinity General Hospital (Weaverville H.S.A.)	1.3	1.5	1.5	200.0

Source: California Department of Health, 1975.

^{a/} Hospital service areas.

^{b/} Chico H.S.A.

^{c/} Redding H.S.A.

inclusion of outpatient visits in the count of emergency room visits. Table 5, however, gives some indication of the instability of usage data. The variability of the data from year to year is quite severe (e.g., Redding hospital service area and Chico hospital service area). These data make future demand projections somewhat speculative. As an illustration of the problems of using different data sources, the last column of Table 5 shows 1972 emergency room visits per 1,000 residents which is comparable to the second column of Table 4. Surprisingly, the EMS usage in a majority of the hospital service areas was comparable between data sources. The Gridley and Fall River Mills hospital service areas, however, exhibited radically different per capita usage patterns between data sources. This inconsistency should encourage a more uniform approach to data collection.

A third data source is the *1968 Ambulance Survey* [California Department of Transportation, 1970]. This study reports the results of a survey of approximately 80 percent of the ambulance providers in California. Table 6 presents selected study area counties and state-wide ambulance utilization data from that report. The number of ambulance trips and number of true emergency ambulance trips have been adjusted for those ambulance providers who did not respond. Butte and Shasta counties reported the study area's highest ambulance utilization rate, with 35.2 and 35.4 ambulance trips per 1,000 residents, respectively. Tehama County's utilization rate was the lowest among the study area counties.

Ambulance trips can be divided into four categories: (1) patients transported to a hospital, (2) patients treated at the scene with no transport, (3) routine transfers, and (4) dry runs. The 1968 Ambulance

TABLE 6---Selected Data From the 1968 Ambulance Survey for the Study Area Counties and State

County	True Emergency Trips											
	<u>Ambulance Trips</u>		Ambulance Trips		Trips Per 1,000 residents		Dry Runs		Traffic accidents		Non-residents	
	Total	per 1,000 residents										Resident Usage/ 1,000 residents
	number		percent	number	number	percent	number	percent	number	percent	number	number
Butte County	3,473	35.2	25	881	8.9	11	100	28	247	12	106	7.9
Glenn County	596	31.9	24	141	7.5	a/	--	68	96	52	74	3.6
Shasta County	2,807	35.4	42	1,169	14.8	7	78	63	740	29	343	10.42
Tehama County	584	20.1	30	176	6.1	14	24	55	97	26	45	4.5
Trinity County	237	26.0	68	160	17.6	3	4	34	54	19	30	14.3
California	839,135	42.6	46.7	391,977	19.9	11	43,117	33	129,352	8	31,358	18.3

Source: California Department of Public Health in contract with the California Department of Transportation, California Ambulance Survey Final Report, 1970.

a/ Dashes indicate data not reported.

Survey tried to ascertain the number of true emergency ambulance trips (categories one and two) in each county during 1968. The percentage of true emergencies and the number of emergency trips per 1,000 1968 residents are also given in Table 6. The highest percent of ambulance trips for true emergencies occurred in Trinity County (68 percent). The state ratios for total ambulance trips and emergency trips per 1,000 residents are considerably higher than for any of the study area counties. The question arises as to why the utilization rate of EMS in the study area is below the average for the state. One might hypothesize that in rural areas, EMS resources are not readily available or not located in a manner allowing easy accessibility to resources.

Table 6 also presents data on emergency ambulance trips which were dry runs, emergency trips for traffic accidents, and emergency trips for nonresidents. Other than Trinity County, which had only three percent dry runs, the study area counties were close to the state average. Glenn, Tehama, and Shasta counties recorded over 50 percent of their true emergency calls being due to traffic accidents. Butte and Trinity Counties were much closer to the state average of 33 percent.

Table 6 also indicates the estimate of ambulance use by nonresidents. Although the ambulance survey report does not specifically reveal how these or other data were verified, it is assumed that these percentages were estimated by ambulance providers. The estimates range from 12 percent in Butte County to 52 percent in Glenn County while the state average is 8 percent. Obviously, in the study area counties, especially Glenn, EMS usage is influenced by nonresidents. But, those counties with the highest

number of true emergency trips per 1,000 residents were least affected by nonresidents. The last column of Table 6 represents true emergency trips per 1,000 residents with the influence of nonresidents removed. The variability of EMS utilization is not reduced by the adjustment. Trinity and Shasta counties have the leading utilization rates for residents among the study area counties.

Estimates of EMS Usage Per 1,000 Residents

A popular measure or "rule of thumb" for estimating EMS resource usage is in terms of visits or trips per area resident per time period. For example, Stevenson [1971] estimated that 35 emergencies per year are generated by every 1,000 people. This estimate is fairly constant for urban populations of less than 500,000, but for places of greater size the ratio is much more variable. The *California 1968 Ambulance Survey* suggested that for the U.S. in general one emergency per day is generated per 10,000 people. For California, the report stated that one emergency per day per 20,000 people is more appropriate. The Dunlop study [1967] reported that for populations of 10,000 or less, every 1,000 people generated approximately 17 calls per year. Obviously, these latter two estimates differ substantially from the former two.

Table 7 summarizes the results of an analysis relating 1968 county resident population to 1968 total ambulance calls. The results are given for all California counties and for rural counties only. The standard linear model was tested with and without a constant term. When the constant term was included, it was not significant at the .05 level. For the state

TABLE 7--Relationship Between Total Ambulance Calls
and Total Resident Population by County, 1968,
for All Counties and Rural Counties Only

Analysis	Constant	Resident population ^{a/}	Degree of freedom	R ²
<u>All Counties</u>				
with constant	-2,361.4 (-1.26) ^{b/}	49.24 (27.19)	53	.93
constant suppressed	--	48.46 (28.4)	54	.93
<u>Rural Counties</u> (with less than 125,000 population)				
with constant	-44.24 (-.25)	30.1 (9.47)	31	.74
constant suppressed	--	29.5 (14.8)	32	.74

Source: Daberkow (1976)

^{a/} Population variable is significantly different from zero at the 5 percent level in all equations.

^{b/} t value is given in parentheses.

as a whole, there are between 48 and 50 ambulance calls generated per 1,000 residents. For rural counties, this estimate drops to between 29 and 30 ambulance calls per 1,000 residents, depending upon which model is used but the coefficient of determination declines when only rural counties are analyzed. For purposes of the location model the estimate of 29.5 calls per 1,000 residents is used.

Resident Population Demand Points

An objective of this study is to analyze the delivery of EMS in a rural environment. Northern California provides such a rural setting. Heavy dependence upon agriculture and forestry, sparsely populated hinterland, and small population clusters scattered unevenly over the area characterize the region designated as the Northern California Health Service Area. The upper end of the Sacramento Valley lies within this area, as do the foothills and mountains of both the Coastal and Sierra ranges bordering the Valley. Discrete geographic points have been chosen to represent geographic areas in the study area. The geographic points represent sources of demand for EMS, and the logical choices for these demand points are population clusters of larger towns and cities. To model the location of population perfectly, each person or household would represent a source of demand. For tractability and statistical reasons, however, the demand points are taken as aggregations of people or households (i.e., towns). Rural areas are particularly hard to model because of the spatially irregular population distribution. The demand points used in this study represent a wide variety of

population distributions within varying geographic shapes. The geographic areas represented by the demand points vary in size (i.e., square miles), population and concentration of that population around the demand point.

Density (people per square mile) is not an adequate measure of the population distribution between areas surrounding demand points because of the variation in population and square miles of these areas. For example, a large population cluster in a large area may have the same density as a small area with a small population. If the former area has all of its population concentrated near the demand point, while in the latter case the population is uniformly distributed over the countryside, then density is not a good comparison of population distribution between the two areas. Therefore, concentration (the percent of the area's population residing in the town designated as a demand point or the percent of the area's population within one mile of the demand point) is a more descriptive measure of population distribution.

The study area (Figure 5) is basically rural with large and small population clusters scattered throughout the area. Table 8 indicates the number of rural and urban places by population category and by county for the study area. These 130 places reflect an approximate spatial location and intensity of demand. Obviously, the rural farm population is dispersed throughout the study area and is not included in these clusters of population.

To further reduce these 130 places to a tractable number of demand points, urban and rural places which have a zip code were considered viable demand points. The assumption was that areas designated by zip

Figure 5 Spatial distribution of the demand points in the study area.

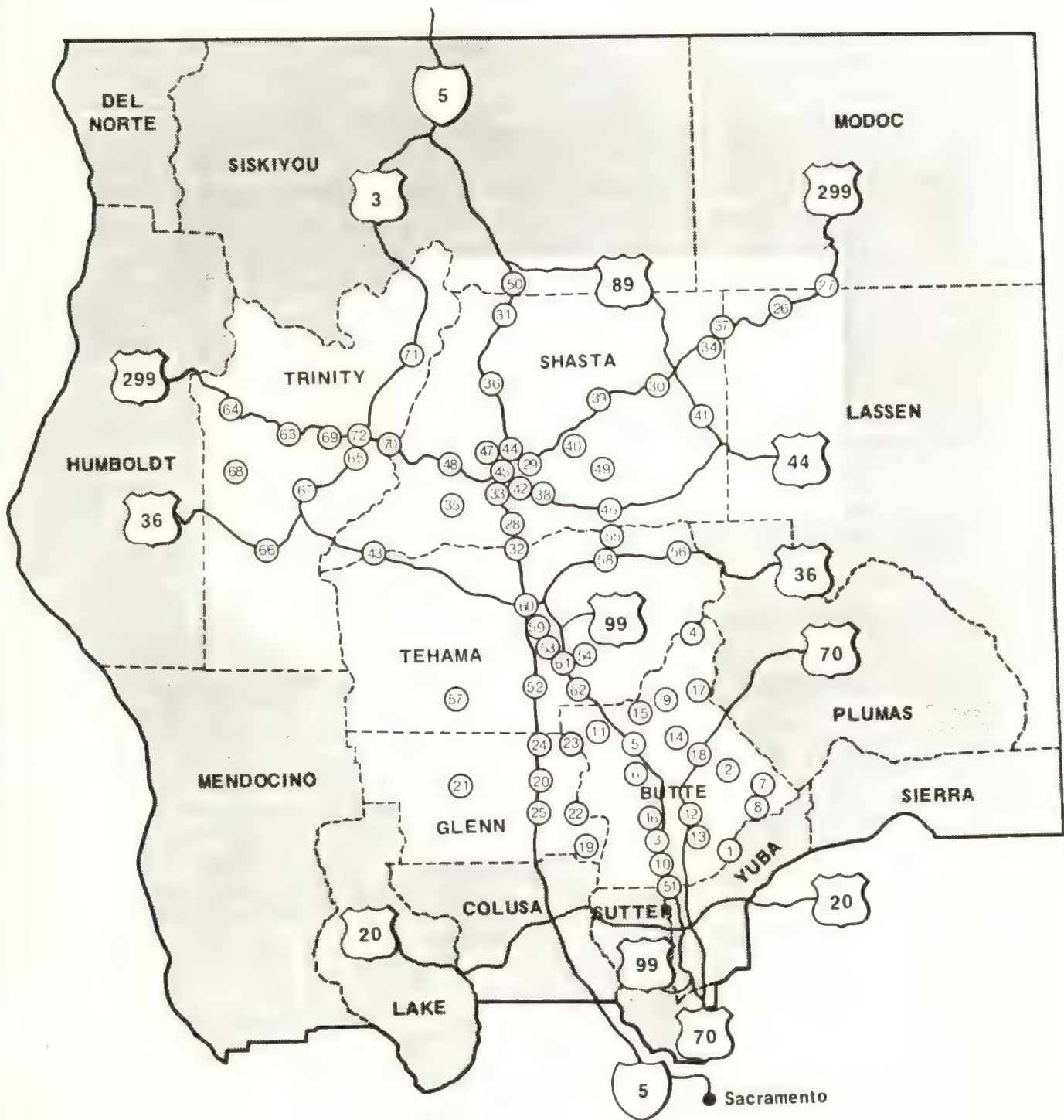


TABLE 8--Number of Study Area Rural and Urban Places by County and Size Range

Population	Butte	Glenn	Shasta	Tehama	Trinity	Total
Rural Places						
0-99	13	5	14	7	13	52
100-199	4	3	9	5	2	23
200-399	9	5	5	2	1	22
400-599	1	0	0	0	0	1
600-799	1	1	3	0	0	5
800-999	0	0	2	1	1	4
1,000-1,499	1	0	2	0	1	4
1,500-1,999	1	0	0	0	0	1
2,000-2,499	0	0	2	0	0	2
Urban Places						
2,500-2,999	0	1	0	0	0	1
3,000-3,999	1	0	0	1		2
4,000-4,999	3	1	1			5
5,000-5,999	0		1			1
6,000-6,999	1					1
7,000-7,999	1			1		2
8,000-8,999	0					0
9,000-9,999	0					0
10,000-14,999	1		1			2
>15,000	1		1			2
Total	38	16	41	17	18	130

Source: California Department of Transportation, City and Unincorporated Place Names (1971).

code had a sufficiently large population to qualify as a demand point. In addition, several geographically separated places were included even though they did not have zip codes. Appendix B lists the demand points and their respective resident populations as well as the Census enumeration districts which surround each demand point. The population associated with each demand point is derived from the 1970 U.S. Census district population estimates or from the California Department of Transportation, *California City and Unincorporated Place Names* [1971]. The boundaries for the area represented by each demand point follow the Census enumeration district boundaries. Each demand point is associated with a particular hospital serving that point; the collection of demand points served by a hospital define a hospital service area.

Due to computer capacity limitations and a shift in the boundaries of the health planning area during the study, the study area was restricted to the counties of Butte, Glenn, Shasta, Tehama, and Trinity plus parts of Siskiyou, Lassen, and Modoc. Table 9 presents the demand points actually used in the analysis. The 72 demand points were assumed to be an adequate representation of the location of population clusters.

Table 9 also indicates the sites chosen to be potential EMS facility sites. The selection of these potential sites follows two general guidelines. First, all cities which are currently served by an EMS facility are automatically included as potential EMS facility locations. Second, the geographic dispersion of demand points may be so sparse that a potential facility must be allowable in that area regardless of the size of the city involved.

TABLE 9--Study Area Demand Points and 23 Potential Facility Sites

1. Bangor	37. McArthur
2. Berry Creek	38. Millville
3. Biggs*	39. Montgomery Creek
4. Butte Meadows*	40. Oak Run
5. Chico*	41. Old Station*
6. Durham*	42. Palo Cedro
7. Feather Falls	43. Platine*
8. Forbestown	44. Project City
9. Forest Ranch	45. Redding*
10. Gridley*	46. Shingletown
11. Nord	47. Summit City
12. Oroville*	48. Whiskeytown*
13. Palermo	49. Whitmore
14. Paradise*	50. Dunsmuir*
15. Richardson Springs	51. Live Oak
16. Richvale	52. Corning*
17. Sterling City	53. Gerber
18. Yankee Hill*	54. Los Molinos*
19. Princeton*	55. Manton
20. Artois	56. Mineral*
21. Elk Creek*	57. Paskenta*
22. Glenn	58. Paynes Creek
23. Hamilton City*	59. Proberta
24. Orland*	60. Red Bluff*
25. Willows*	61. Tehama
26. Bieber*	62. Vina
27. Adin*	63. Big Bar
28. Anderson	64. Burnt Ranch*
29. Bella Vista*	65. Douglas City
30. Burney	66. Forest Glen*
31. Castella	67. Hayfork*
32. Cottonwood	68. Hyampom
33. Enterprise	69. Junction City
34. Fall River Mills*	70. Lewiston
35. Igo	71. Trinity Center*
36. Lakehead	72. Weaverville*

*Potential facility sites.

To assess the degree to which the study area's population is represented by discrete demand points, Table 10 was constructed showing 19 of the 72 demand points which are large enough (i.e., greater than 1,000 population) to have a satisfactory population estimate in the 1970 Census of Population. Table 10 presents the census estimate for the resident population of the selected demand point (town), the total population of the surrounding area which is represented by that demand point (see Appendix B for enumeration districts that make up the surrounding area), and the percent of the total population which is within the city limits of the demand point under consideration.

The large percentages in the last column indicate that a high degree of an area's population is represented by the demand point in question. The percentages range from 37.3 percent to 100 percent. The overall average was 70.5 percent. Thus, on the average, about 30 percent of an area's population is outside of the 19 demand point's limits. Little can be said for the distribution of this population without more detailed information on house locations within large rural census tracts.

The 19 demand points represent 198,818 of the study area population of 244,062, with 45,244 not represented. If other demand points given in Table 9 are assumed to represent 70.5 percent of these 45,244 people, then 13,347 or 5.5 percent of the study area's total population is not represented by specified demand points. Due to lack of detailed residence information, these people are assumed to be represented by the demand points given in Table 9. The use of discrete demand requires the assumption that distances between potential EMS facilities and the various demand points are average distances.

TABLE 10--Population by City and Area Represented by City, 1970

Demand point	U.S. Census population of city (1970)	Area population assumed to be repre- sented by the city	City/Area Population
	number		percent
Chico ^{a/}	32,818	40,193	81.7
Oroville ^{b/}	15,864	21,060	75.3
Palermo	1,966	5,270	37.3
Paradise	14,598	14,598	100.0
Gridley	3,534	7,808	45.3
Biggs	1,115	2,084	53.5
Live Oak	2,645	4,811	55.0
Orland	2,884	6,602	43.7
Willows	4,085	6,010	68.0
Burney	2,190	2,633	83.2
Anderson	5,492	14,164	38.8
Cottonwood	1,288	2,574	50.0
Project City ^{c/}	3,792	7,031	53.9
Enterprise	11,416	11,486	99.4
Redding ^{d/}	21,541	27,181	79.3
Dunsmuir	2,214	2,819	78.5
Red Bluff	7,676	14,497	52.9
Corning	3,573	6,508	54.9
Weaverville	1,489	1,489	100.0
Total	140,180	198,818	70.5

Source: U.S. Bureau of The Census (1972)

^{a/} Includes Chico North, Chico West, Chico, and Mulberry^{b/} Includes Oroville, South Oroville, and Thermalito^{c/} Includes Project City and Central Valley^{d/} Includes Redding and Bonneyview

Nonresident Population Estimates:
Recreation Population and Transient Population

Northern California experiences a large influx of people seeking outdoor recreation. In addition, Interstate 5 serves as a major transportation artery along the West Coast, so large numbers of transients pass through the area. An attempt must be made to estimate the total population at risk at a given time; therefore, the non-resident population must be added to the resident population.

Available data on the recreation population visiting Northern California is limited to estimates of visitor-day use at various public recreation sites. Recreation use data are available from the U.S. Forest Service, California Parks and Recreation Department, U.S. Department of the Interior, the National Park Service and from the Pacific Gas and Electric Company (see Appendix C). The public organizations which provided the bulk of these data stress that the estimates of recreation site usage are imprecise since the areas under their responsibility are very large, and only organized campgrounds and national parks utilize systematic counting techniques. Private recreation sites are not included in the estimates, but second home tracts located within U.S. Forest boundaries are included.

The influx of nonresidents into Northern California is a seasonal phenomenon. According to some health planning authorities [Northern California Emergency Medical Care Council, personal interview, 1970], the concentration of nonresidents in Northern California during the summer

months is the critical problem confronting the EMS system. Fortunately, many of the data sources report recreation use by month as well as by site. One source, the U.S. Forest Service, however, does not report monthly use data and, therefore, several assumptions were made about the seasonal recreation use of forest land. The methods used to estimate monthly recreation use are described in Appendix C.

Recreation use statistics are commonly quoted in terms of visitor-days. The U.S. Forest Service defines a visitor-day as one person present at a site for 12 hours or conversely 12 persons present at one site for one hour or any combination of people and hours which equals 12. Hence, visitor-days combine a time dimension with a pure count dimension. The visitor-day concept is used throughout the study. Furthermore, the resident population was put on a time basis, called resident-days, making addition with the nonresident population possible. To avoid double counting, use of recreation sites by the local population was also taken into account (see Appendix C).

U.S. Forest Service Data. The federal government owns over one-third of the land in the study area and the majority of the federally-owned land is administered by the U.S. Forest Service. The study area includes parts of the Lassen, Mendocino, Shasta, Six Rivers, Trinity, and Plumas National Forests. The Forest Service (1972) records recreation use by various geographical delineations such as counties, forests, and ranger districts (R.D.). The ranger districts are the smallest areas within a National Forest for which visitor-day data are available. In a rather arbitrary manner, the visitor-days are associated with a particular

ranger district. Although this is a gross assumption, no other data are available to more rationally locate the people involved in outdoor recreation activities. In some instances, the visitor-days for a particular ranger district are divided between two or three demand points due to the proximity of a ranger district to several demand points (see Appendix Table C-2). Appendix Table C-5 presents the total number of visitor-days present at each demand point during 1972. The same table also presents estimates of monthly recreation use for demand points located within or near the U.S. Forests. Although specific data are not available by month, U.S. Forest personnel are aware of the peak usage months during the year [personal interview, 1974]. In general, recreation use in the U.S. Forests is minimal during the winter months, with activity slowly increasing to Memorial Day. Recreation use then normally declines slightly until a few days before July 4. Peak usage occurs between July 4 and Labor Day. Usage then gradually declines until October 1, when activity again becomes minimal. This pattern changes for certain forested areas where skiing and big game hunting account for a significant amount of the recreation use.

Another component of the nonresident population at risk at any demand point is the transient population which only passes through a demand point but does not live there or visit a recreation site. Obviously the transient population is more evident on the major transportation routes through the study area, such as Interstate 5. An examination of data in Appendix C, however, indicates that during the summer months, transient population increases significantly on several of the

smaller state highways which pass through the study area. Estimates of the transient population were made from traffic flow data (see Appendix C). A conversion factor of 2.4 persons per vehicle, while not well-substantiated, is considered an appropriate measure and is used by transportation agencies for planning purposes (California Department of Transportation, personal interview, 1974).

Details of the seasonal pattern of demand are given in Appendix C (see especially Table C-3). Given the assumptions used in allocating non-residents to specific demand points, several of these demand points experience significant fluctuations in population during the year. One criterion to use in identifying the demand points with greatest variation in population is the comparison of resident-days with the total population-days during the month of peak nonresident influx. August is generally the peak influx month. Appendix Table C-3 indicates that approximately 20 demand points have very large increases in nonresident population during August. The following demand points exhibit a ratio of total population-days to resident-days greater than 1.5:

<u>Butte County</u>	<u>Shasta County</u>	<u>Tehama County</u>	<u>Trinity County</u>
Butte Meadows	Lakehead	Paskenta	Big Bar
Feather Falls	Platina	Mineral	Burnt Ranch
Yankee Hill	Whiskeytown		Junction City
	Old Station		Lewiston
	Castella		Trinity Center
			Weaverville

The outlying demand points of Butte County are influenced by the visitors to the Lassen and Plumas National Forests. The nonresident influx into Shasta County is influenced by the Shasta National Recreation

Area, Whiskeytown National Park, Trinity National Forest and Lassen National Forest. Tehama County experiences an influx of visitors near Mineral because of Lassen National Park and Lassen National Forest, while in the vicinity of Paskenta, the Trinity and Mendocino National Forests attract a relatively large number of recreationists. Trinity County has several small communities scattered throughout the Trinity National Forest. With the influx of transients into the forests during the summer months, residents comprise a relatively small part of the total population at some of the demand points.

The problem of a large influx of a recreation population appears to affect nearly all demand points to some degree. The implication for EMS is two-fold. First, many of the smaller communities are not currently served by any organized form of emergency medical care. Second, smaller communities exhibit a relatively small demand during a large part of the year, but during the summer season, demand for EMS may exceed the EMS resources which are available. The larger communities in the study area also experience an increase in demand for EMS during the summer months. Most of these demand points, however, already have existing EMS providers; and, therefore, the problem is one of absorbing increased demand. Apparently this is accomplished through longer service and response time or these providers may have excess capacity during the remainder of the year.

The data from Appendix Table C-3 are used to derive demand estimates for EMS which include the usage by the nonresidents in the study area. One problem, of course, is the aforementioned differences among data

sources. Another is that of an aggregation-type problem. The assumption used in Appendix Table C-3 was that three populations--residents, visitors, and transients--can be combined into one population which collectively expresses demand for EMS.

Estimate of EMS Usage Per 1,000 Population-Days

Appropriate data were not available to estimate accurately the relation between hospital service area population-days and ambulance calls. (Ambulance use data are by county for 1968, while population-days estimates are available by hospital service area for 1972.) As a crude estimate of this relation, however, one could assume that the ratio of ambulance calls per resident to hospital emergency room visits per resident is equal to the ratio of ambulance calls per population-day to hospital emergency room visits per population-day.^{1/} For example,

^{1/} Data for point estimates (using ordinary least squares [OLS] without a constant) of the following ratios were available: (1) hospital emergency room visits per 1,000 resident population (r_1); (2) hospital emergency room visits per 1,000 population-days (r_2); and (3) ambulance calls per 1,000 residents (r_3). (See Chapter 5 of Daberkow [1976] for a derivation of the above regression coefficients.) Making the necessary assumptions about the stability of the ratios over time (due to different years used in calculating the ratios), the following proportion was hypothesized:

$$\frac{r_3}{r_1} = \frac{X}{r_2} \text{ where } X = \text{ambulance calls per 1,000 population-days.}$$

In other words, the relation assumes that the ratio of the number of ambulance calls per 1,000 population-days to hospital emergency room visits per 1,000 population-days is equal to the ratio of the number of ambulance calls per 1,000 residents to hospital emergency room visits per 1,000 residents. Note that r_1 , r_2 , and r_3 were estimated using ordinary least squares and were significant at the .05 level. Since r_1 is an estimate of R_1 (population parameter), then r_1 is a random variable with a distribution having mean R_1 and variance σ^2 . Therefore, $X = \frac{r_2 r_3}{r_1}$ also has a distribution but it is unknown and, therefore, no statistical tests of significance can be made.

$$\frac{29.5 \text{ ambulance calls/1,000 population}}{252 \text{ emergency room visits/1,000 population}} =$$

$$\frac{X \text{ ambulance calls/1,000 population-days}}{0.372 \text{ emergency room visits/1,000 population-days}} .$$

This calculation gives an estimated .0435 ambulance calls per 1,000 population-days. This value was multiplied by the estimated number of population-days at each demand point during the peak recreation month of August to derive EMS demand estimates.

The location algorithm requires point estimates of the demand for ambulance calls at each demand point. Annual EMS demand of 29.5 ambulance calls per 1,000 residents was taken from Table 7, while .0435 ambulance calls per 1,000 population-days was chosen to represent the peak month demand (August). Table 11 presents the expected EMS demand (in total ambulance calls) for each demand point. The regional population was estimated to generate 7,163 calls throughout the year (244,062 residents times 29.5 calls per 1,000 population). Nonresidents generate additional calls during certain months of the year due to the summer recreation opportunities available in the area. Residents plus nonresidents generate 666 calls for the entire region during the month of August (16,061,200 population-days times .0435 calls per 1,000 population-days). Both the annual demand and peak month demand estimates were truncated rather than rounded.

V. LOCATION OF FACILITIES

Currently, there are 15 locations serving the EMS demands of the area. Here, the existing system is compared with optimal locations for

TABLE 11--Location and Number of Expected EMS Calls by Demand Point

Demand point	Expected annual demand	Expected peak month demand	Demand point	Expected annual demand	Expected peak month demand
1	14	1	37	23	2
2	12	1	38	17	1
3	61	5	39	26	2
4	11	1	40	38	3
5	1185	105	41	19	3
6	91	8	42	10	1
7	6	1	43	3	1
8	8	1	44	207	26
9	8	1	45	801	71
10	230	20	46	15	1
11	15	1	47	20	1
12	621	58	48	26	9
13	155	13	49	4	1
14	430	38	50	83	7
15	87	7	51	141	12
16	18	1	52	191	17
17	39	3	53	21	1
18	9	1	54	97	8
19	30	2	55	12	1
20	17	1	56	3	8
21	32	3	57	17	2
22	36	3	58	9	1
23	58	5	59	46	4
24	198	17	60	427	38
25	177	16	61	9	1
26	26	2	62	33	3
27	19	1	63	9	1
28	417	37	64	20	2
29	49	4	65	14	1
30	77	9	66	6	1
31	16	2	67	44	4
32	75	7	68	16	1
33	338	29	69	12	2
34	41	3	70	30	4
35	44	3	71	8	1
36	17	9	72	43	5

Source: See Appendix B and C.

given levels of demand and response and service time standards. Emphasis is given to the trade-off in (a) total costs and (b) percentage of population served as the response time standard is increased from 13 minutes (a standard often promulgated for an urban area by health planners) to 67 minutes.^{1/} The latter is considered an upper limit to effective response time.

Response Time Standards - Resident Population

Given the existing system with 15 EMS facilities and a 13-minute response time, 42 of the 72 demand points cannot be served.^{2/} These 42 points represent about 25 percent of the population of the entire area. As the time standard is relaxed by increments of approximately 13 minutes, the number of sites needed is reduced until at a 67-minute response time the number of sites could be reduced from the existing 15 to only 8. Then the entire population would be served at a cost of about 57 percent of that for the simulated 13-minute situation. Results for these and other response times are shown in the bottom half of Table 12 for the present system.

A more detailed listing of demand points served with the present location pattern of EMS facilities is given in Table 13. The 15 sites

^{1/} The response times were selected to correspond to the time an ambulance traveling an average of 45 miles per hour would require to travel 10, 20, 30, 40, and 50 miles, respectively.

^{2/} The algorithm requires that all demand points be served within at least 67 minutes. When a smaller response time is imposed, not all demand points can be reached within that time. Of course, all demand points could be served within a given time standard if an EMS facility could be established at each demand point. However, this was assumed to be fiscally infeasible and, therefore, only 32 of the demand points were allowed to be potential facility sites.

TABLE 12--Response Time Standards: Comparison of Selected
Parameters for the Optimal and Present Location
Patterns of EMS Facilities (Annual Demand)

Response time standard (in minutes)	Number of facilities	Total annual cost	Demand points not served	Percentage of total population served
	no.	mil. \$	no.	pct.
-----Optimal System-----				
13	31	2.24	22	86.2
27	22	1.62	11	97.7
40	15	1.13	1	99.8
53	9	0.71	0	100.0
67	8	0.64	0	100.0
-----Present System-----				
13	15	1.13	42	75.1
27	14	1.06	21	95.5
40	12	0.92	9	98.4
53	9	0.71	1	100.0
67	8	0.64	0	100.0

TABLE 13--Present Location of EMS Facilities as Possible Sites: Results for Selected Response Times (Based on Annual Demand Estimates)

Present EMS facility sites	Demand points served by each potential facility site for selected response times									
	13 minutes		27 minutes		40 minutes		53 minutes		67 minutes	
	Demand point indices	No. of patients	Demand point indices	No. of patients	Demand point indices	No. of patients	Demand point indices	No. of patients	Demand point indices	No. of patients
Chico 5	4,5,6,9,11,15	1,397	4,5,6,9,11,15	1,397	4,5,6,9,11,15, 22,23	1,491	4,5,6,9,11,14, 15,17,62	1,899	1,2,3,4,5,6,7,8,9, 10,11,12,13,14,15, 16,17,18,19,51,62	3,204
Gridley 10	3,10,19,22,51	498	3,10,19,22,51	498	1,2,3,7,8,10,12, 13,16,19,51	1,296	1,2,3,7,8,10,12, 13,16,18,19,51	1,305		
Oroville 12	1,2,7,8,12,13,16	834	1,2,7,8,12,13,16	834						
Paradise 14	14,17,18	478	14,17,18	478						
Elk Creek 21	21	32	21	32	14,17,18	478	20,21,22,23,24, 25,52,57	722	20,21,22,23,24,25, 52,57	732
Orland 24	20,23,24,25	446	20,23,24,25	446	21,25	209				
Breber 26	26	26	26,27	45	26,27	45				
Adin 27	27	19	30,34,37,41	160	30,34,37,41	160	26,27,30,34,37, 41	205	26,27,30,34,37,41	205
Fall River Mills 34	30,34,37,41	160								
Redding 45	28,29,33,35,36,38, 39,40,42,44,45,46, 47,48,49	2,029	28,29,33,35,36, 38,39,40,42,44, 45,46,47,48,49	2,029	28,29,33,35,36, 38,39,40,42,44, 45,46,47,48,49	2,029	28,29,33,35,36, 38,39,40,42,44, 45,46,47,48,49	2,029	28,29,33,35,36,38, 39,40,42,44,45,46, 47,48,49	2,209
Dunsmuir 50	31,50	99	31,50	99	31,50	99	31,50	99	31,52	99
Corning 52	52,54,57,61,62	347	52,54,57,61,62	347	20,24,52,54,57, 61,62	558	32,53,54,55,56, 58,59,60,61	699	32,53,54,55,56,58, 59,60,61	699
Red Bluff 60	32,53,55,56,58,59,60	593	32,53,55,56,58, 59,60	593	32,53,55,56,58, 59,60	593				
Hayfork 67	43,66,67,68	69	43,66,67,68	69	43,66,67,68	69				
Weaverville 72	63,64,65,69,70,71,72	136	63,64,65,69,70, 71,72	136	63,64,65,69,70, 71,72	136	63,64,65,69,70, 71,72	136	63,64,65,69,70,71, 72	136
Total annual cost	\$1,125,380		\$1,055,403		\$916,456		\$707,178		\$641,047	
Total annual patients		7,163		7,163		7,163		7,163		7,163
Demand points not meeting the time constraint	1,2,4,7,8,9,11,15,16,17,18, 19,22,23,25,28,29,30,32,35, 36,38,39,40,41,42,43,46,48, 49,54,55,56,57,58,62,63,64, 66, 68, 70, 71		4,7,8,19,22,36,39,40, 41,43,46,49,55,56,57, 58,63,64,66,68,71		4,39,41,43,46,49,55, 56,64		56			

in existence when the study was undertaken are listed in the first column of the table. With a 13-minute response time, 42 sites are not served within the stated time constraint. These points are listed in the last row of Table 13. When the response time standard is increased, locations not served within the required time, of course, decrease, and the number of facilities needed also decreases. Figure 6 gives the present system solution for a 13-minute response time standard with areas to be served encircling the blocked location site.

An optimal location of facilities under these same response time standards and demand conditions is also given in Table 12. To meet the 13-minute standard, EMS facilities would have to be located at 31 of the 32 potential sites (see Table 12). However, 22 demand points still would not be served under this time constraint, or about 14 percent of the area population. One should note that in order to serve 100 percent of the population within 13 minutes, more than 32 facility sites are required. The location of sites is given in Table 14.

The trade-off between response time standards and system cost is shown in Figure 7 where costs drop sharply as the number of facilities decreases and response time increases. The percentage of the population served, however, increases as response time increases. For a 13-minute response, 86 percent of the population is served, but for a 27-minute response time and location of 22 facilities, about 98 percent of the population is served. The location pattern of EMS facilities and demand points served by those facilities for the 40-minute response time is given in Figure 8.

Figure 6 Facilities and Demand Points associated with those facilities using the 13 minute response time standard (present system servicing annual demand)

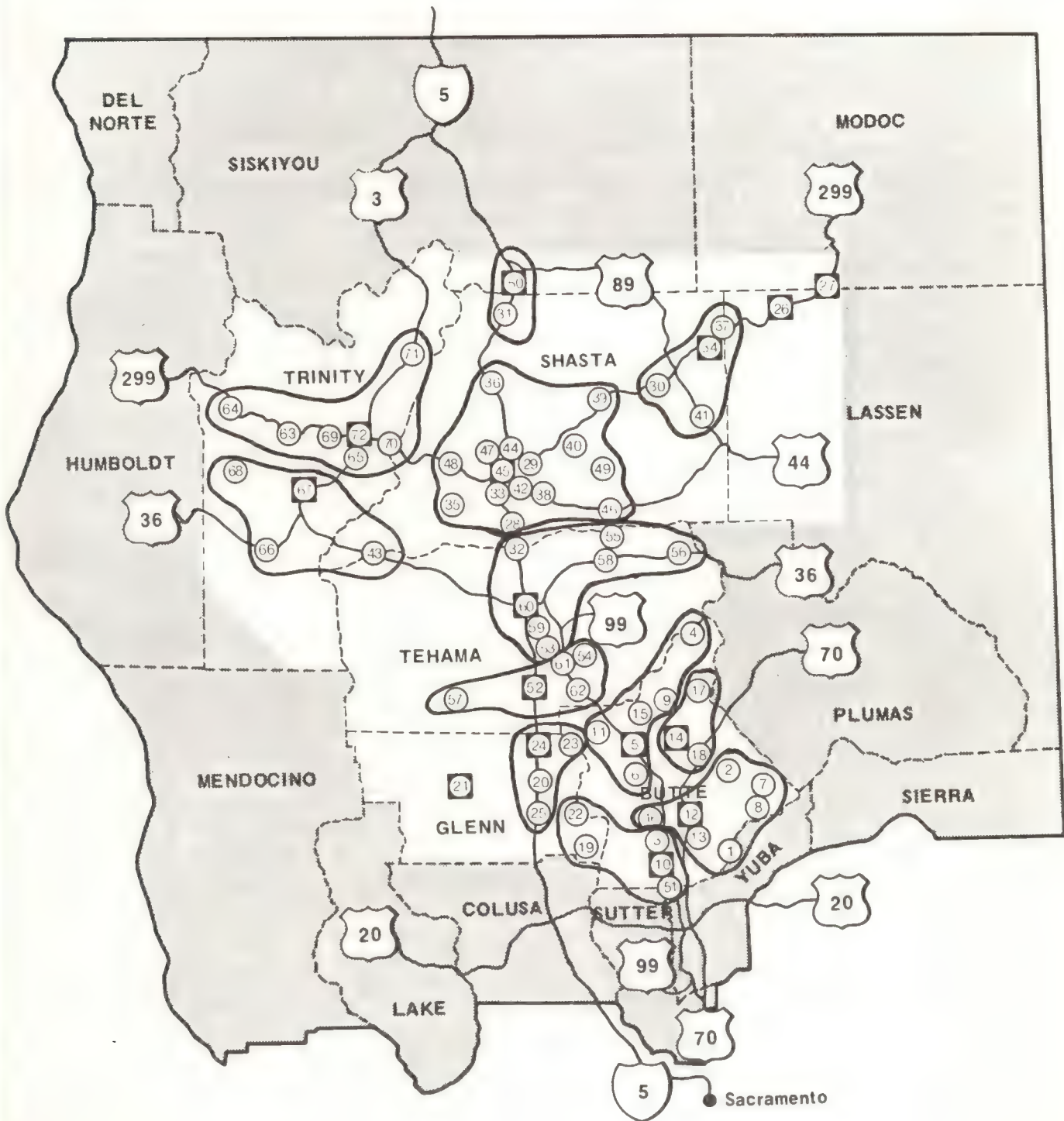


TABLE 14—Optimal Location of EMS Facilities: Results for Selected Response Times (Based on Annual Demand Estimates)

Potential sites	Demand points served by each potential facility site for selected response times									
	13 minutes		27 minutes		40 minutes		53 minutes		67 minutes	
	Demand point indices	No. of patients	Demand point indices	No. of patients	Demand point indices	No. of patients	Demand point indices	No. of patients	Demand point indices	No. of patients
Biggs 3	3,16	79								
Butte Meadows 4	4	11	4	11	4,9	19				
Chico 5	5,6,9,15	1,371	5,6,9,11,15,23,62	1,477			4,5,6,9,11,14,15,17,62	1,899		
Durham 6										
Gridley 10	10,51	371	3,10,51	432						
Oroville 12	1,2,7,8,12,13	816	1,2,7,8,12,13,16	834	1,2,3,7,8,10,12,13,16,51	1,266	1,2,3,7,8,10,12,13,16,18,19,51	1,305	1,2,3,7,8,10,12,13,14,16,17,18,51	1,744
Paradise 14	14,17	469	14,17,18	478	5,6,14,15,17,18	1,841				
Yankee Hill 18	18	9								
Princeton 19	19,22	66								
Elk Creek 21	21	32	21	32						
Hamilton City 23	11,23	73							5,6,9,11,15,19,20,21,22,23,24,25,52,53,54,57,59,61,62	2,344
Orland 24	24	194					20,21,22,23,24,25,52,53,54,57,59,61	895		
Willows 25	20,25	194	19,20,22,24,25,26,27	454	19,20,21,22,25,26,27,34,37	292				
Bieber 26	26	26		45		109				
Adin 27	27	19								
Bella Vista 29	29,38,39,40,42,46,49	159	29,38,39,40,42,46,49	180	28,29,33,35,38,39,40,42,44,45,46,47,48,49	2,012	28,29,32,33,35,38,39,40,42,44,45,46,47,48,49,55,60	2,526		
Fall River Mills 34	30,34,37	141	30,34,37	141			26,27,30,34,37,41	205	26,27,30,34,37,41	205
Old Station 41	41	19	41	19	30,41	96				
Platina 43	43	3	43	3						
Redding 45	28,33,35,36,44,45,47	1,844	28,33,35,36,44,45,47,48	1,870					28,29,32,33,35,36,38,39,40,42,44,45,46,47,48,49,55,60	3,543
Whiskey Town 48	48	26								
Dunsmuir 50	31,50	99	31,50	99	31,36,50	116	31,36,50	116	31,50	99
Corning 52	52	191			11,23,24,52,54,57,61,62	614				
Los Molinos 54	53,54,59,61,62	206								
Mineral 56	56,58	12	56,58	12	56,58	12	56,58	12	4,56,58	23
Paskenta 57	57	17	57	17						
Red Bluff 60	32,55,60	514	32,32,53,54,55,59,60,61	857	32,53,55,59,60	581				
Burnt Ranch 64	63,64	29	63,64	29	63,64	29				
Forest Glen 66	66	6	66	6	43,66	9				
Hayfork 67	67,68	60	67,68	60	67,68	60	43,66,67,68	69	43,66,67,68	69
Trinity Center 71	71	8	71	8						
Weaverville 72	65,69,70,72	99	65,69,70,72	99	65,69,70,71,72	107	63,64,65,69,70,71,72	136	63,64,65,69,70,71,72	136
Total annual regional cost	\$2,244,319		\$1,615,298		\$1,128,816		\$709,262		\$639,678	
Total calls		7,163		7,163		7,163		7,163		7,163
Demand points not meeting the time constraint*	1,2,7,8,9,15,17,28,30,32,35,36,38,39,40,46,49,55,58,63,68,70		7,8,36,39,40,46,47,49,55,58,68		55					

*Since potential facility sites do not exist at all demand points, several demand points cannot be served within the time constraint. In these cases, the demand points are served by the closest potential facility site.

Figure 7 Relation Between Response Time, Total Regional Cost, and Percentage of Population Served Within Various Response Times (optimal system)

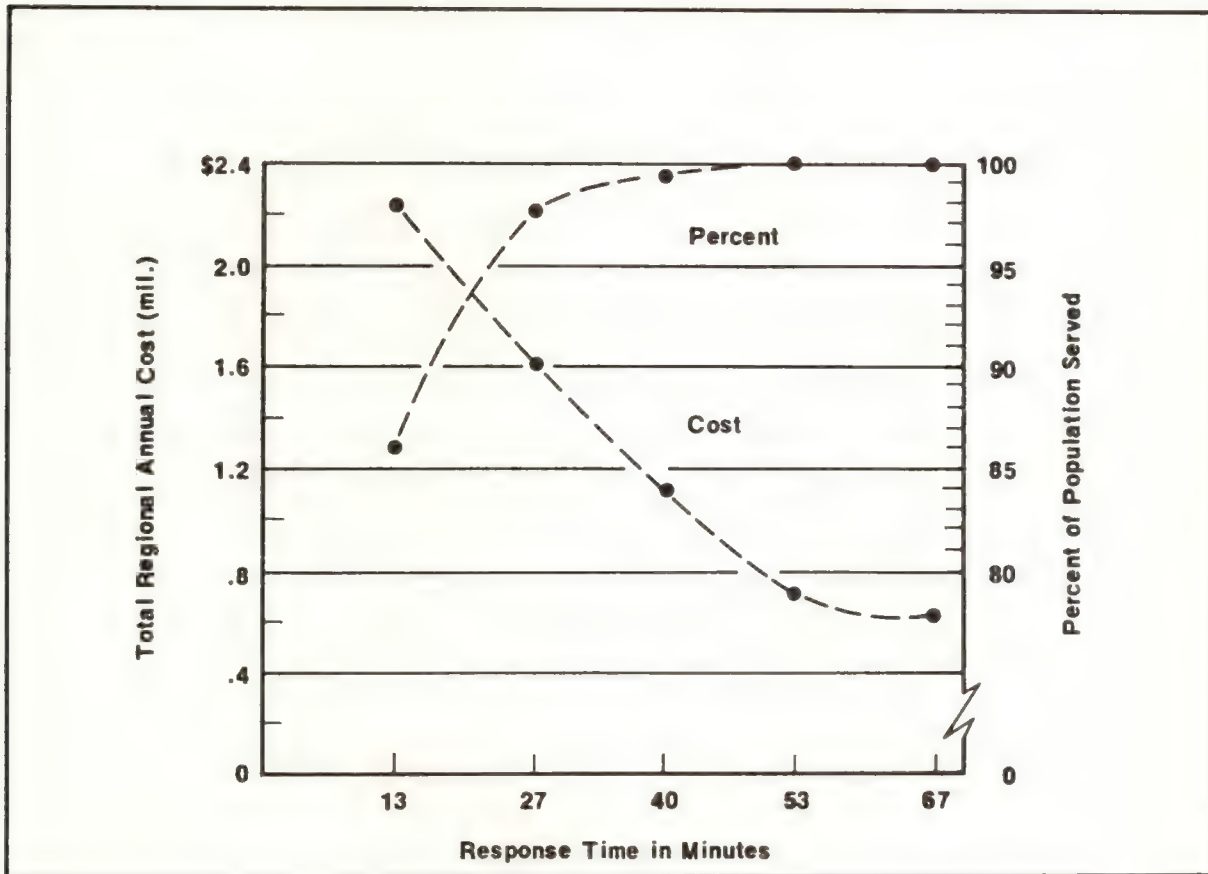
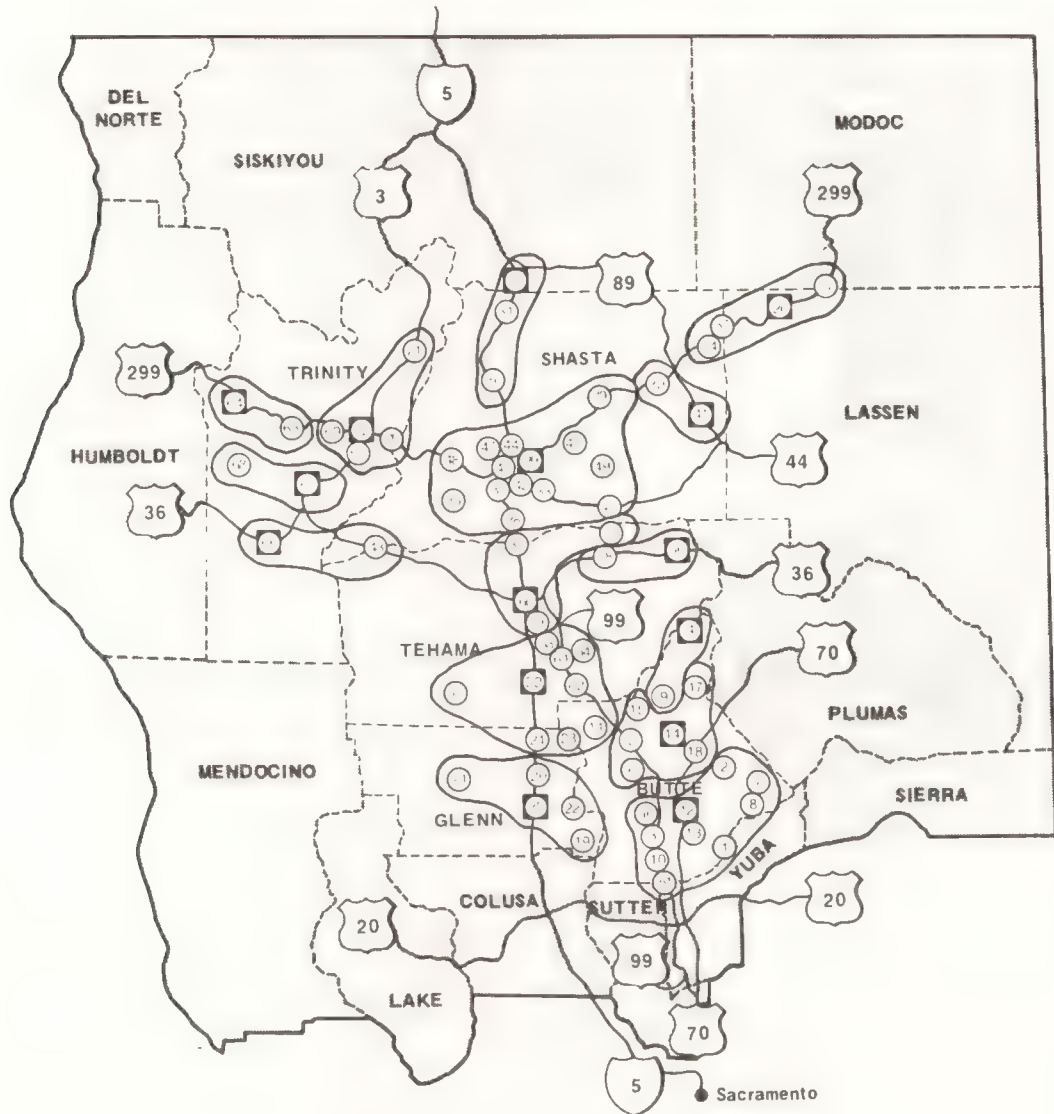


Figure 8 Facilities and Demand Points associated with those facilities using the 40 minute response time standard (optimal system)



The standards promulgated in the 1974 California State Plan for EMS suggest that 90 percent of the population for low density areas should be within 30 minutes of an EMS facility. The 27-minute response time standard meets this criterion. The total cost of this system is \$1.6 million.

Response Time Standards - Peak Month Demand

The peak nonresident demand occurs during the summer months, particularly in August. If the goal of the EMS system is to locate permanent facilities to meet the peak month demand of residents and nonresidents at minimum cost, the analysis must be modified. The approach was to estimate the number of population-days for nonresident population associated with the various demand points based on estimated traffic flows and visits to parks and forests as given in the previous section. Demand for EMS was assumed to be a function of the number of population-days at each demand point.

The overall location of facilities did not change substantially from that given previously; however, the pattern changed for some of the points. For example, under the 40-minute response constraint, Forest Glen served Platina on an annual demand basis. Using peak month demand, however, it is more efficient for Platina to have its own facility with Hayfork serving Forest Glen. The annual costs were slightly higher due to travel costs for more patients. Also, there were slight reductions in the percentage of population served within given response time standards due to the use of remote recreation areas by nonresidents. The

current location of sites is given in Table 15; the optimal location, in Table 16.

Service Time Standards

Service time is defined as the total time between notification of an accident and delivery of the patient to the nearest hospital. Service standards were arbitrarily set at twice the corresponding response time standards to evaluate the trade-off between costs and service time. The general results were similar to those presented for response time. There were a few differences, however, in the location of facilities for the service and response time standards. Given locations of hospitals, the service time model locates EMS facilities so as to minimize backtracking. Figure 6 indicates the location (number in parentheses) of the following study area hospitals: Chico (5), Paradise (14), Oroville (12), Gridley (10), Willows (25), Redding (45), Fall River Mills (34), Red Bluff (60), Corning (52), and Weaverville (72).

VI. FINANCIAL ANALYSIS OF EMS FACILITIES AND FUNDING ALTERNATIVES

This section is concerned with the economic viability of the EMS facilities which entered the optimal solutions. The 40-minute and 27-minute response time spatial patterns are examined in detail to show the costs and revenues for each EMS facility which entered the optimal solutions. Although other response times could have been analyzed, the 40-minute and 27-minute response times seemed most appropriate for a semirural area. The 27-minute standard most nearly approximates the 30-minute standard

Table 15--Present Location of EMS Facilities as Possible Sites: Results for
Selected Response Times (Based on Peak Month Demand)

Indices of po- tential facility site	Demand points served by each potential facility site for selected response times									
	13 minutes		27 minutes		40 minutes		53 minutes		67 minutes	
	Demand point indices	No. of pa- tients	Demand point indices	No. of pa- tients	Demand point indices	No. of pa- tients	Demand point indices	No. of pa- tients	Demand point indices	No. of pa- tients
5	4,5,6,9,11,15	123	4,5,6,9,11,15	123	4,5,6,9,11,15, 22,23	131	4,5,6,9,11,14,15, 17,62	167	1,2,3,4,5,6,7,8,9, 10,11,12,13,14,15, 16,17,18,19,51,62	283
10	3,10,19,22,51	42	3,10,19,22,51	42						
12	1,2,7,8,12,13,16	76	1,2,7,8,12,13,16	76	1,2,3,7,8,10,12, 13,16,19,51	115	1,2,3,7,8,10,12,13, 16,18,19,51	116		
14	14,17,18	42	14,17,18	42	14,17,18	42				
21	21	3	21	3	21,25	19				
24	20,23,24,25	39	20,23,24,25	39			20,21,22,23,24,25, 52,57	64	20,21,22,23,24,25, 52,57	64
26	26	2	26,27	3	26,27	3				
27	27	1								
34	30,34,37,41	17	30,34,37,41	17	30,34,37,41	17	26,27,30,34,37,41	20	26,27,30,34,37,41	20
45	28,29,33,35,36,38, 39,40,42,44,45,46, 47,48,49	198	28,29,33,35,36,38, 39,40,42,44,45,46, 47,48,49	198	28,29,33,35,36, 38,39,40,42,44, 45,46,47,48,49	198	28,29,33,35,36,38, 39,40,42,44,45,46, 47,48,49	198	28,29,33,35,36,38, 39,40,42,44,45,46, 47,48,49	198
50	31,50	9	31,50	9	31,50	9	31,50	9	31,50	9
52	52,54,57,61,62	31	52,54,57,61,62	31	20,24,52,54,57, 61,62	49				
60	32,53,55,56,58,59,60	60	32,53,55,56,58,59, 60	60	32,53,55,56,58, 59,60	60	32,53,54,55,56, 58,59,60,61	69	32,53,54,55,56,58, 59,60,61	69
67	43,66,67,68	7	43,66,67,68	7	43,66,67,68	7	43,66,67,68	7	43,66,67,68	7
72	63,64,65,69,70,71,72	16	63,64,65,69,70,71	16	63,64,65,69,70, 71,72	16	63,64,65,69,70, 71,72	16	63,64,65,69,70,71, 72	16
Total cost	\$1,134,852		\$1,064,864		\$925,952		\$716,712		\$649,652	
Total peak month patients	666		666		666		666		666	

NOTE: See Table 13 for indices of demand points which do not meet the time constraint.

TABLE 16--Optimal Location of EMS Facilities: Results for Selected Response Times (Based on Peak Month Demand)

Potential site indices	Demand points served by each potential facility site for selected response times									
	13 minutes		27 minutes		40 minutes		53 minutes		67 minutes	
	Demand point indices	No. of patients	Demand point indices	No. of patients	Demand point indices	No. of patients	Demand point indices	No. of patients	Demand point indices	No. of patients
3	3,16	6								
4	4	1	4	1	4,9	2				
5	5,6,9,15	121	5,6,9,11,15,23,62	130			4,5,6,9,11,14,15,17,62	167	1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,22,23,51	288
6										
10	10,51	32	3,10,51	37						
12	1,2,7,8,12,13	75	1,2,7,8,12,13,16	76	1,2,3,7,8,10,12,13,16,51	113	1,2,3,7,8,10,12,13,16,18,19,51	116		
14	14,17	41	14,17,18	42	5,6,14,15,17,18	162				
18	18	1								
19	19,22	5								
21	21	3	21	3						
23	11,23	6								
24	24	17					20,21,22,23,24,25,52,53,54,57,59,61	78		
25	20,25	17	19,20,22,24,25	39	19,20,21,22,25	25				
26	26	2	26,27	3	26,27,34,37	8				
27	27	1								
29	29,38,39,40,42,46,49	13	29,38,39,40,42,46,49	14	28,29,33,35,38,39,40,42,44,45,46,47,48,49	189	28,29,32,33,35,38,39,40,42,44,45,46,47,48,49,55,60	235		
34	30,34,37	14	30,34,37	14			26,27,30,34,37,41	20	26,27,30,34,37,41	20
41	41	3	41	3	30,41	12				
43	43	1	43	1	43	1				
45	28,33,35,36,44,45,47	176	28,33,35,36,44,45,47,48	185					28,29,33,35,36,38,39,40,42,44,45,46,47,48,49	198
48	48	9								
50	31,50	9	31,50	9	31,36,50	18	31,36,50	18	31,50	9
52	52	17			11,23,24,52,54,57,61,62	54			20,21,24,25,52,54,57,61,62	68
54	53,54,59,61,62	17								
56	56,58	9	56,58	9	56,58	9	56,58	9		
57	57	2	57	2						
60	32,55,60	46	32,52,53,54,55,59,60,61	76	32,53,55,59,60	51			32,53,55,56,58,59,60	60
64	63,64	3	63,64	3	63,64	3				
66	66	1	66	1						
67	67,68	5	67,68	5	66,67,68	6	43,66,67,68	7	43,66,67,68	7
71	71	1	71	1						
72	65,69,70,72	12	65,69,70,72	12	65,69,70,71,72	13	63,64,65,69,70,71,72	16	63,64,65,69,70,71,72	16
Total annual regional cost	\$2,253,148		\$1,624,252		\$1,138,102		\$718,620		\$649,412	
Total calls during August	666		666		666		666		666	

promulgated by health planning agencies. The initial discussion pertains to the present revenue structure for EMS purveyors in Northern California. Related to this topic is the rate of noncollectible charges experienced by ambulance operators. In addition, the procedure for calculating EMS facility costs and revenues is made explicit.

Revenue Structure

Conversations with health planning officials (Northern California Emergency Medical Care Council and Superior California Comprehensive Health Association) indicated that private ambulance operators in the study area commonly charge a basic rate per call, a mileage rate, and a charge for use of incidentals (e.g., linens, bandages, oxygen, splints, resuscitator, etc.) (According to the *1968 Ambulance Survey* [California Department of Transportation, 1970], some ambulance purveyors also charge extra for night calls and emergency calls [p. 137].) The basic charge per call is \$45 plus \$2 per mile transport charge. The charge for supplies is highly variable, depending on the circumstances of the medical emergency. For purposes of this study, the charge for supplies was assumed to be \$10 per call based on conversations with area ambulance providers. The transport charge was assumed to be \$2 per mile where the total transport mileage consisted of the distance from the demand point to the nearest hospital. The set of demand points served by each hospital is given in Appendix B. No distinction is made between patient transfers (i.e., hospital to hospital or hospital to other points) and emergency calls.

The *1968 Ambulance Survey* (California Department of Transportation, 1970) as well as the study area's health planning personnel reported that

the collection rate, particularly from individuals without health insurance or those not qualifying for Medicare or Medi-Cal, is much less than 100 percent. According to the survey, 14 percent of rural ambulance services collected less than half of their charges, 35 percent collected between 50 and 74 percent, 43 percent collected between 75 and 89 percent and 4 percent collected 90 to 100 percent of their charges (p. 132).

Insurance companies and the Medicare and Medi-Cal agencies often times pay only a certain percent of a bill submitted by an ambulance purveyor. Based on the above, it is assumed that the total charge is collected from 80 percent of the calls. No provision is made for dry runs, although adjustments in the cost estimates could be made to allow for such occurrences.

Table 17 indicates several financial measures which can be used to evaluate the economic viability of the EMS facilities optimally located to serve the region's annual demand within a 40-minute response time. Table 18 reports the same numbers for the 27-minute response time. The wide variation in costs and revenues among the various facilities is obviously due to the large difference in total number of calls serviced by each EMS facility. The facilities which served the largest number of calls for either response time standard had the lowest cost per call. Oroville, Paradise, Chico, Redding, Willows, Gridley, Corning, and Red Bluff were in this category. The remaining facilities had very high costs per call due to the extremely low number of calls serviced per year. The highest revenue per call is generated in the more remote areas such as Elk Creek, Hayfork, Burnt Ranch, Forest Glen, Mineral, Old

TABLE 17--Financial Analysis of the 15 Facilities Entering Optimal Program
with 40-Minute Response Time (Annual Demand Model)

Facility site	Fully-staffed facility (24 hours per day)					Volunteer facility for < 400 calls per year	
	Total calls	Cost/ call	Revenue/ call	Cost per resident		Cost per resident	
	no.			Average	Net	Average	Net
				dollars			
45 Redding ^{a/}	2,012	46	54	1.36	-0.23	<u>b/</u>	<u>b/</u>
14 Paradise ^{a/}	1,841	49	48	1.45	0.05	<u>b/</u>	<u>b/</u>
12 Oroville ^{a/}	1,266	66	49	1.94	0.51	<u>b/</u>	<u>b/</u>
52 Corning ^{a/}	614	125	59	3.66	1.94	<u>b/</u>	<u>b/</u>
60 Red Bluff ^{a/}	581	129	51	3.79	2.31	<u>b/</u>	<u>b/</u>
25 Willows	292	250	54	7.34	5.77	.82	0.06
50 Dunsmuir ^{a/}	116	614	64	17.88	16.02	1.79	0.75
26 Bieber ^{a/}	109	654	64	19.15	17.28	1.94	0.89
72 Weaverville ^{a/}	107	655	60	19.09	17.38	1.91	1.01
41 Old Station	96	741	78	21.67	19.39	2.19	0.72
67 Hayfork ^{a/}	60	1,177	102	34.54	31.56	3.35	1.18
64 Burnt Ranch	29	2,424	98	69.00	66.21	6.54	4.55
4 Butte Meadows	19	3,695	90	107.02	104.40	10.08	8.27
56 Mineral	12	5,845	84	153.81	151.60	14.43	12.95
66 Forest Glen	9	7,789	121	204.97	201.79	19.16	16.72
Study Area	7,163	158	53	4.63	3.06	2.01	0.54

^{a/} Indicates cities which currently either have commercial or volunteer ambulance services.

^{b/} Facilities with greater than 400 calls per year where costs equal those shown in columns to the left.

TABLE 18--Financial Analysis of the 22 Facilities Entering the Optimal Solution
with a 27 Minute Response Time Standard (Based on the Annual Demand
Model)

Facility site	Fully-staffed facility (24 hours per day)					Volunteer facility for < 400 calls per year	
	Total	Cost/	Revenue/	Cost per resident		Cost per resident	
	calls no.	call	call	Average	Net	Average	Net
					dollars		
45 Redding	1,870	48	53	1.41	-0.14	**	**
5 Chico	1,477	58	48	1.70	0.27	**	**
60 Red Bluff	878	89	51	2.62	1.13	**	**
12 Oroville	834	94	49	2.77	1.34	**	**
14 Paradise	478	157	48	4.61	3.19	**	**
25 Willows	454	165	57	4.85	3.17	**	**
10 Gridley	432	172	49	5.06	3.63	**	**
29 Bella Vista	159	458	78	13.17	10.93	1.55	0.11
34 Fall River Mills	141	508	61	14.84	13.05	1.53	0.55
50 Dunsmuir	99	717	60	20.98	19.23	2.07	1.14
72 Weaverville	99	718	57	20.64	19.00	2.06	1.22
67 Hayfork	60	1,177	101	34.54	31.56	3.35	1.18
26 Bieber	45	1,566	87	46.03	43.47	4.41	2.67
21 Elk Creek	32	2,198	81	64.64	62.26	6.12	4.57
64 Burnt Ranch	29	2,424	98	69.00	66.21	6.54	4.55
41 Old Station	19	3,694	100	107.82	104.90	10.13	8.03
57 Paskenta	17	4,128	82	115.99	113.67	10.89	9.36
56 Mineral	12	5,845	84	153.81	151.60	14.43	12.95
4 Butte Meadows	11	6,374	103	185.48	182.48	17.34	15.16
71 Trinity Center	8	8,760	90	245.04	242.51	22.87	21.12
66 Forest Glen	6	11,677	127	305.94	302.61	28.52	25.92
43 Platina	3	23,343	108	619.74	616.87	57.66	55.53
Study Area	7,163	225	53	6.62	5.06	2.70	1.22

** Facilities with greater than 400 calls per year where costs equal to those shown in the columns to the left.

Station, Platina, Trinity Center, Paskenta, and Butte Meadows. These facilities generate larger revenues per call because of their distance from a hospital; and, thus, the \$2 per mile charge becomes significant.

Rather than attempting to cover all costs through patient payments, two alternative funding mechanisms are presented in the fourth and fifth columns of Tables 17 and 18. Should the local residents decide to support a 24-hour per day EMS facility within a 40-minute or 27-minute response, then these columns of Table 17 and 18, respectively, are relevant. As would be expected, the facilities which serve the fewest number of people must shoulder a much higher cost per resident. The residents served within 40 minutes by Butte Meadows, Mineral, Forest Glen, and Burnt Ranch facilities have particularly high burdens. Butte Meadows, Old Station, Platina, Mineral, Paskenta, Forest Glen, and Trinity Center have very high per unit costs under the 27 minute constraint. Obviously, such a high annual per resident cost may prohibit the establishment of an EMS facility at those points. If the total study area, however, decided to provide an EMS system on a regional basis, the annual cost per regional resident would be \$4.63 in the first situation and \$6.62 in the second. If the present revenue structure were utilized (i.e., user fee collected), the regional per resident cost would fall to \$3.06 for the 40-minute standard and \$5.06 for the 27-minute standard.

Funding Alternatives for Low Volume EMS Facilities

Given the exceedingly high costs of sustaining an EMS facility which serves a low number of annual calls, it seems appropriate to discuss several alternatives available to these facilities. Facilities may

employ one or more of the following techniques to ensure economic viability. The discussion is divided into two parts. The first part is concerned with funding alternatives which will allow the maintenance of a high quality EMS system as proposed in this study. The exact standards of this 24-hour per day, 365 days per year system are given in Appendix A. The second part of the discussion centers on alternatives which involve reduction in the quality of EMS in the low demand areas of the region.

Subsidy Schemes

The funding alternatives needed to maintain a high quality EMS system revolve around a variety of direct subsidy schemes or indirect subsidies which are designed to reduce competitive pressures. These subsidy schemes can originate at the local, regional, state, or federal level. At the local (i.e., area served by one facility) level, the city, county, or regulatory body in charge of EMS can institute an indirect subsidy by creating spatial monopolies for the EMS purveyor whether it be a privately or publicly owned concern. Such an ordinance or regulation essentially reduces or eliminates competition for ambulance calls. Thus, franchising, exclusive contracts, and zoning allow EMS facilities to exploit more fully the decreasing average costs exhibited by the facilities.

Direct subsidies at the local level can also take a variety of forms. Local tax revenues can be used to reimburse the EMS purveyor for non-collectible charges, dry runs, or indigent patients not covered by Medicare or Medi-Cal. These funds might be obtained by forming an EMS tax

district. Estimates for the size of the per call subsidy can be taken from Tables 17 and 18.^{1/}

If a regional EMS regulatory body (e.g., the Northern California Emergency Medical Care Council or the Northern California Health Systems Agency), regional funding measures might be applicable. In this case, the regional operation of EMS facilities might be arranged similarly to that of a cooperative. Questions of public or private ownership and operation of the facilities would immediately arise. Perhaps the profits of the economically viable operators might be used to assist the economically depressed purveyors. An alternative might be a regional (multi-county) taxing district to raise the necessary revenue. Tables 17 and 18 provide estimates of the per call subsidies needed for a regional subsidy arrangement.

Subsidy measures which use state or federal tax funds represent a fundamental shift in philosophy from previous funding schemes which obtained revenue from EMS users or from local or regional tax sources. State and federal tax funds are collected from residents but also from nonresidents of the study areas. In other words, the user or immediate

^{1/} The use of prepaid EMS is another possibility. There are two problems here: (a) the costs would be prohibitive unless funding is on a regional basis and low density areas would be subsidized by high density areas and (b) since EMS is rarely denied anyone in need of emergency care, a "free rider" problem develops. One reviewer noted that demand may be affected by this type of financial mechanism. The simultaneous nature of demand, location, and type of payment is acknowledged, but the investigation of such a system was beyond the scope of this study. This question is also commonly debated with regard to the issue of national health insurance.

potential user of the EMS facility does not fully pay the cost of the service. The argument most often given by proponents of the out-of-region subsidy, centers on the use of EMS facilities by nonresidents. Due to the presence of a major highway and extensive recreational opportunities in the study area, nonresidents constitute a large proportion of potential EMS users. Since nonresidents are rarely denied access to local EMS resources, a case can be made for the state or federal governments helping to shoulder the burden of funding EMS facilities. Funding mechanisms are described below.

At the state level, at least one funding alternative is operational--the state sales tax. Currently one percent of this tax is returned to the governments of the cities and counties from which it was collected. The returned money was collected from residents of the area as well as nonresidents passing through or temporarily staying in the area. The money collected from nonresidents can conceivably be viewed as payment to the local government for services rendered to the nonresident (e.g., streets, roads, parks, police, and fire protection). The use of a portion of this money for the support of an EMS system to be utilized by nonresidents as well as residents seems appropriate.

Grants, either at the state or federal level, also offer funding opportunities. Federal and state agencies, as well as some private foundations, concerned with EMS have, in the past, been willing and able to provide equipment directly or funds with which to purchase ambulances, communication equipment, etc. Regional Medical Programs, Robert Wood Johnson Foundation, Cranston Funds (P.L. 93-154), and the California Office of

Traffic Safety are examples of organizations which have contributed to EMS resources. The grantee, however, needs to be aware of the circumstances surrounding the grant. Unless the grant is an annual stipend for an extended length of time, the receiver can only use the stipend to offset costs for a short period of time. This may be ideal if demand for EMS is expected to grow to levels sufficient to make the EMS facility economically viable. Direct donations of EMS equipment are essentially annual grants over the depreciated life of the equipment. At the end of that period, another piece of equipment, or some similar subsidy must again be found.

Should none of the above funding measures be adequate to sustain EMS at the quality level proposed in the analysis, quality might be reduced. This reduction could range from the elimination of an EMS to a modification of the EMS system analyzed above. Modification could mean that small isolated population clusters will be served by EMS facilities outside the specified response or service time applicable to the majority of the population. Another alternative modification scheme is the establishment of a volunteer emergency medical service. A volunteer system may not be as well-trained or responsive as the system analyzed in this study. If a governing agency (i.e., city, county or health planning board) is not willing or is unable to fund an EMS facility, or if a private purveyor is unable to operate economically, then a reduction in quality or even cessation of EMS is unavoidable.

Volunteer Systems

The last two columns of Tables 17 and 18 present projected costs for a volunteer EMS system. Only facilities serving less than 400 calls a

year were considered candidates for a volunteer system. The annual fixed cost estimate of \$6,500 is based on the following assumptions: (1) no labor overhead (no full-time drivers or attendants, or paid clerical staff); (2) rent, phone, and utilities at one-half the cost of the full-time system; and (3) insurance and depreciation at the same level as the full-time system. Revenues generated are based on a \$20 per call charge plus \$2 per mile to the nearest hospital with the collectible portion still at 80 percent.

The general conclusion from Tables 17 and 18 is that volunteer systems are more attractive from a cost-per-resident standpoint as well as from the cost-per-patient view. Facilities with annual usage of less than 50 calls per year, however, are still faced with relatively large per unit and total costs. In such low usage areas the only alternatives may be to rely on FMS facilities outside of the 40-minute or 27-minute response time boundary or not provide EMS in any form.

VII. SUMMARY AND CONCLUSIONS

Uses of the Model

The location analysis in this report utilized spatial EMS demand estimates representing population clusters in the study area. Using estimated annual cost of EMS facilities and transport costs, the location algorithm determined the optimal (least-cost) size, number, and location of EMS facilities. The location analysis was performed under varying circumstances. Solutions were found for estimated annual demand and for resident plus nonresident demand in the peak usage month. The above solutions were constrained by two measures of effective EMS delivery: response

time and service time. The optimal solutions from the above analyses were compared to the solutions which allowed only existing EMS facilities to enter. In addition to the size, number and location of facilities, the results provided total annual regional cost of the EMS system as well as the demand points served by each facility.

Very little difference in location analysis results was found between annual demand based on per capita data and peak month demand based on resident plus nonresident data. The implication for health planners is that the influx of nonresidents does not change the optimal location pattern of EMS facilities found for the resident population. This does not mean, however, that the nonresident influx problem disappears, for even though EMS facilities are optimally (least-cost) located to serve nonresident demand, individual facilities may experience periodic increased need for their services. The increase in demand is no problem if the facility is underutilized during the remainder of the year, but if the facility was operating at capacity then increased service and/or response times for all users--resident and nonresident--would result.

Two measures of EMS system effectiveness were also evaluated: response time (time from the notification of an emergency situation to the arrival of an ambulance at the scene) and service time (time from the notification of an emergency situation to the arrival of an ambulance at a given destination--usually the nearest hospital). The EMS facility location patterns varied somewhat between the two measures. As would be expected, the service time criterion, in general, located EMS facilities by proximity to a hospital, while the response time locational pattern was influenced

primarily by the size and location of demand points. From a health planner's point of view, the choice between the two measures should rest on their respective influence on mortality and morbidity. A response time measure accentuates the importance of an ambulance reaching the scene of an emergency quickly and initiating treatment. Service time implies that rapid transport to a nearby hospital is of critical importance.

Locational patterns also varied according to whether a large number of potential facility sites were allowed to enter the solution (the optimal system) or whether only the existing facility sites were allowed to enter. The comparison of the existing spatial arrangement with the optimal location pattern indicated a possible pattern toward which the present system could adjust over time. Because of the large number of facilities called for in the optimal solution, the system would be much more costly to maintain than is the present system. Under the present system, however, large numbers of people cannot be served within the various time standards--particularly the 13- and 27-minute standards. Hence, decision makers are faced with the trade off between cost and people served, within the various time standards.

From the results of this study health planners can examine these trade offs under the various response and service time standards proposed for a regional EMS system. The standards can be set to match those of an urban area (response time of 15 minutes or less) or can be lowered to a response time of over an hour. As would be expected, as time standards are weakened, costs fall.

The discussion highlights a critical aspect of EMS delivery--the type of the region under consideration. A highly concentrated population within a region requires fewer facilities than does a region with a highly dispersed population, given the same time standards and same total population. Suppose the standard for the State of California required that 90 percent of the residents have EMS available within 30 minutes. Such a standard is already met, since nearly all major and minor urban areas have EMS facilities; but in rural or semirural areas (as in this study) a very low percentage of the residents are currently within 30 minutes of EMS. The problem is one of efficiency versus equity: should the state's limited EMS resources be distributed in a least-cost manner or on an equitable basis to the total population? Establishing comparable EMS for the remaining 10 percent of the state's population may be more costly than the benefits derived therefrom in dollar terms, but such a goal might be desirable from an equity or fairness goal.

Funding alternatives range from revenues generated entirely by fee-for-service to complete public funding through taxes or some other subsidy form. All funding alternatives can be viewed from a local, regional, state or federal level. The local analysis identified several sparsely settled rural areas which generated very few ambulance calls per year. Such areas could support a sophisticated, fast response EMS facility only at a very high cost per patient or through high cost per resident via taxes. Subsidies (including direct equipment donations) through a regional EMS system, or from state or federal sources are potential sources of revenue for such areas. Several of the more densely

populated areas within the study area had EMS facilities which were economically viable through user fees. Such facilities were able to exploit the economies of size aspect of EMS production.

Sparsely settled rural areas which cannot generate revenues or subsidies to support an EMS facility of the caliber suggested in this study do have other alternatives. In the past, these areas have sacrificed some quality in EMS service to reduce costs. Establishing a volunteer EMS rather than a full-time facility is an obvious way to reduce costs (and possibly lose quality). Other communities, for various reasons, have not established any EMS, but rely on distant EMS facilities or private autos and accept the consequences.

Extensions of the Analysis

Several extensions and refinements to the basic model are possible. The demand for EMS, which is proportional to population size in this model, may be investigated further as better utilization data become available. For example, it was assumed in this model that a serious accident or acute illness generates a need for an ambulance irrespective of the price of the medical and transport service. It is also plausible to expect some price elasticity for EMS depending upon the degree of seriousness or acuteness. The demand for routine transfers (i.e., hospital to hospital, hospital to home, etc.) is likely to be very elastic or at least related to the insurance coverage of the patient. Public awareness or education about the desirability and/or the availability of EMS also plays an important role in the usage of these services. Again, little

data are available concerning public awareness of EMS availability. With the introduction of a "911" emergency telephone number, public awareness may be enhanced.

Another problem with assessing demand lies with the supply of EMS. The data show that up to 80 percent of the arrivals at a hospital emergency room with "true" emergencies arrive in a private auto. Is this due to a lack of immediate EMS resources or to ignorance on the part of consumers or both? Is the public aware of the benefits of using a trained EMS staff in conjunction with rapid transport instead of merely using a private auto in a true emergency situation? If no EMS resources are nearby, of course, then private auto is the only form of transport available.

The influx of nonresidents into the study area during certain times of the year poses an additional demand problem. Some rather admittedly crude aggregations of visitation and traffic data sources were attempted. Should better estimates become available, they can be incorporated readily into the analysis. The impact of nonresidents on the EMS system should not be taken lightly. Due to the increases in leisure time and incomes the attraction of the many recreation sites in Northern California, the influx of nonresidents into the area will continue to grow.

Once the facilities have been located, the question of capacity or number of ambulances becomes paramount. This study is not specifically concerned with this aspect of EMS planning. The answer to such a question depends partially on the demand level and time period one considers. In this study, the shortest time period analyzed was one month--the demand

level for the peak usage month. Shorter periods of time (a week, a weekend, or even one hour) may exhibit high EMS demands. In providing for the possibility of disaster, the health planner or EMS facility manager must consider what length of peak demand period to plan for when deciding on the number of ambulances. Queueing theory is the applicable technique for such an extension of the analysis. The location model used here essentially assumed that an ambulance was available at all times at each potential facility site. Most study area EMS facility sites utilized a very old, fully depreciated vehicle as a backup ambulance. Costs for such a backup are minimal, but its usefulness in an emergency situation may be questionable.

A valuable addition to the analysis would be that of dynamics or time phasing of facilities. A time path accounting for projected spatial demand would allow planners to move from the present location pattern of facilities to one more nearly optimal at some future date. The uncertainty of the location of demand and its intensity offers another challenge to health planners. The systems approach to EMS planning, used in this study, assumed that various subsystems such as public education, communications, transport, manpower development, and disaster planning to be at a constant level. Perhaps a simulation analysis would provide a more comprehensive approach. An examination of the relations between each of various components of the EMS system and the reduction in mortality and morbidity would be very useful.

Throughout the analysis presented earlier, the location of EMS facilities was assumed not to influence the demand or usage of EMS. If such

an assumption is unwarranted, what is the interaction of EMS supply and demand? Finally, the present study does not deal with the stability of optimal location patterns with respect to changes in costs or in demand over time. Sensitivity analysis could provide some answers in this area.

Forms of emergency transport other than the ground ambulance were not considered in the analysis. Helicopters, airplanes, and water vehicles can be alternatives to the ground based system in some areas. These transport forms could be included in the analysis. Earlier studies indicated that the cost of air transport forms tended to be prohibitive (see Plaas *et al.* [1975]). In addition, inclement weather reduces the effectiveness of air transport during certain times of the year. Water transport systems are limited to specialized geographical areas for obvious reasons.

The study also ignored secondary EMS resources such as the availability of personnel and equipment from the U.S. Forest Service, California Highway Patrol, and other governmental agencies located in the study area. It was felt that EMS was not the main function of these agencies but rather an occasional service rendered. Such assistance, therefore, should not be included in planning an EMS system.

Conclusions

A primary purpose of the study was to minimize costs of EMS delivery, given various objectives and standards suggested by the State Department of Health. The study does show that several of these standards can be met more efficiently through a spatial reallocation of facilities.

Setting goals or standards at some arbitrarily high level, no matter how noble the goal, requires substantial financing. Prescribing standards which are acceptable or common in urban areas may be prohibitively costly to rural residents because of the low number of consumers, their widespread spatial dispersion, and the inability of EMS to exploit economies of scale in serving such a small number. In addition, rural area residents tend to have lower incomes and may exhibit different tastes, preferences, and attitudes about EMS than their urban counterparts.

Currently one finds that instead of an urban type EMS system in rural areas, these areas have adopted EMS systems reflecting a choice of lower personal and public expenditures. Hence, volunteer systems or long response times are common in rural areas, and rural residents accept a higher level of risk with regard to injury and death. It may be that other services common in urban areas are also less sophisticated in rural areas. Fire and police services, sanitation, medical care, transportation services, communication, energy distribution, education and other social services such as welfare, and city and county planning agencies may reflect an area's lack of fiscal resources. Sources of financing for such services must be viewed in a broader-than-local context including state and federal tax structures. Recommendations on funding of a particular service, such as EMS, would be presumptuous without analysis of all demands on a rural economy. Whatever the major category of service-delivery under consideration, however, if the goal is efficiency, then the analysis should be on a broad enough regional basis to allow consideration of locational reorganization.

The emphasis of this study is on the cost side of providing a regional EMS system. From a societal viewpoint, the benefits or medical payoffs (reduction of death, disability, and suffering) must be provided to define the optimal level of EMS. At present, such data are not available. Indeed, the impact of time-to-treatment on mortality and morbidity is a much debated topic in medical circles. This study, however, provides much of the needed framework and information for more rational decision making.

8/28/79

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APPENDIX A

Ambulance Cost Estimates

The cost estimates derived on the following pages are based on data and techniques from two sources: (1) Dunlop and Associates, Inc. [1968], *Economics of Highway Emergency Ambulance Service*, and (2) the California Ambulance Association [personal interview, 1975]. Ambulance firm costs differ because of manning variations in: the number of policies for drivers and attendants; the combination of managerial, clerical and dispatching personnel; employee fringe benefits; facility size and rent; the type of complementary enterprises (e.g., medical supply, taxi services, etc.); advertising and legal costs; the number of ambulances, and the type of service area (square miles, size of population, roads, terrain, etc.). In addition, some firms are able to take advantage of substantial discounts on vehicles, supplies, and equipment, available with bulk purchases.

Dunlop and Associates [1968] estimated that approximately 85 percent of total costs are fixed; the remainder, variable (i.e., on a per call basis). Labor costs, which account for about 60 percent of the total cost of private providers, are the single most expensive item. According to Dunlop, government ambulance services tend to pay higher salaries than do private providers, while the volunteer services obviously have very small expenditures for labor. The labor cost per hour used in this study is based on the 1974 minimum wage.

ALTERNATIVE BUDGETS

I. Driver/Attendant (D/A)--Annual wages under various manning policies

Assumptions:

- 1) 24-hour service/day, 365 days/year; 24 hours x 365 days x 2 persons = man-hours required.
- 2) 2-person crew on call at all times.
- 3) Emergency Medical Technician--I (EMT-I) training level.
- 4) Calculations are for one-manned ambulance--additional manned ambulances are multiples of these calculations.
- 5) Average number of calls per unit time is constant over a 24-hour period. This assumption could be modified to allow, for example, for increased demand during daytime hours.)
- 6) A private provider. Government or volunteer services will have different costs than the private purveyor especially for labor costs.

MANNING POLICY A

Assumptions: 40 hours/week/man
 No overtime
 1 week paid vacation/year (40 hours)
 1 week paid sick leave and downtime (vehicle repair) and technical training/year
 \$2.00/hour wage (present minimum wage)

Calculations:

40 hours x 50 = 2,000 hours/year

$\frac{17,520}{2,000}$ man-hours required = 8.76 men required/year

2,000 hours x \$2.00/hour = \$4,000/year (salary)
 80 hours x \$2.00/hour = $\frac{160}{\text{year}}$ (vacation/sick leave)
 \$ 4,160/year/man

\$4,160/year/man x 8.76 men = \$36,442/year total wages for system.

MANNING POLICY B₁ (Typical Situation)

Assumptions: On duty 24 hours--off duty 24 hours. (Average of 84 hours on duty/week.)
 \$2.00/hour wage for 40 hours/week/man
 \$4.00/hour wage (twice minimum wage) for work in excess of 40 hours
 Personnel receive 5 hours uninterrupted sleep and 2 hours meal time; demand for ambulance service is sufficient to provide an average of 17 hours of work during 24-hour duty shift.*
 1 week paid vacation
 1 week sick leave and downtime.

Calculations:

84 hours/week x 50 weeks = 4,200 hours on duty/year/man

$\frac{17,520}{4,200}$ man-hours required = 4.17 men required/year

17 hours work/shift x 3.5 shifts/week = 59.5 hours work/week

2,000 hours/year @ \$2.00/hour = \$4,000/year (base) (40 hours/week x 50 weeks)

975 hours/year @ \$4.00/hour = 3,900/year (overtime) (19.5 hours/week x 50 weeks)

80 hours/year @ \$2.00/hour = $\frac{160}{\$3,060}$ (vacation/sick leave) /year/man

\$3,060/year/man x 4.17 men = \$33,610/year total wage for system.

MANNING POLICY B₂ (Minimum Situation)

Assumptions: Same as for B₁ except demand for emergency service provides an average of only 13 hours work/24-hour shift (i.e., 8 hours of uninterrupted sleep and 3 hours meal time).*

Calculations:

84 hours/week x 50 weeks = 4,200 hours on duty/year/man

$\frac{17,520}{4,200}$ man-hours required = 4.17 men required/year

13-hour work shift x 3.5 shifts/week = 45.5 hours worked/week

2,000 hours/year @ \$2.00/hour = \$4,000/year (base) (40 hours/week x 50 weeks)

275 hours/year @ \$4.00/hour = 1,100/year (overtime) (5.5 hours/week x 50 weeks)

80 hours/year @ \$2.00/hour = $\frac{160}{\$5,260}$ (vacation/sick leave) /year/man

\$5,260/year/man x 4.17 men = \$21,934.

*See end of Manning Policies for explanation of asterisk.

MANNING POLICY C₁ (California Typical Situation)

Assumptions: Eleven 24-hour on duty shifts/2-week period. (Average of 132 hours on duty/week.)
 \$2.10/hour wage for 40 hours/week/man
 \$3.15/hour wage for hours in excess of 40 hours (1-1/2 times base rate)
 Demand is sufficient to provide 16 hours of work/24-hour shift.*
 1 week paid vacation/year
 1 week paid sick leave and downtime and training/year.

Calculations:

132 hours/week x 50 weeks = 6,600 hours on duty/year/man

$\frac{17,520}{6,600}$ man-hours required = 2.65 men required/year

17 hours work/shift x 5.5 shifts/week = 93.5 hours work/week

2,000 hours/year @ \$2.10/hour = \$ 4,200/year (base) (40 hours/week x 50 weeks)

2,675 hours/year @ \$3.15/hour = 8,426/year (overtime) (53.5 hours/week x 50 weeks)

80 hours/year @ \$2.10/hour = $\frac{168}{\$12,794}$ /year (vacation/sick leave) /year/man

\$12,794/year/man x 2.65 men = \$33,904/year total wages for system.

MANNING POLICY C₂ (California Minimum Situation)

Assumptions: Same as C₁ except demand for emergency service provides an average of only 13 hours work/24-hour shift.*
 Employees are guaranteed 13 hours of work regardless of the number of calls received.

Calculations:

132 hours/week x 50 weeks = 6,600 hours on duty/year/man

$\frac{17,520}{6,600}$ man-hours required = 2.65 men required/year

13 hours work/shift x 5.5 shifts/week = 71.5 hours work/week

2,000 hours/year @ \$2.10/hour = \$4,200/year (base) (40 hours/week x 50 weeks)

1,575 hours/year @ \$3.15/hour = 4,961/year (overtime) (31.5 hours/week x 50 weeks)

80 hours/year @ \$2.10/hour = $\frac{168}{\$9,329}$ /year (vacation/sick leave) /year/man

\$9,329/year/man x 2.65 men = \$24,722 total wages for system.

*See end of Manning Policies for explanation of asterisk.

*"When personnel are hired to work a shift of at least 24 hours, minimum wage and hour legislation exempts the employer from paying for three hours legitimate eating and eight hours sleeping period provided the employees have five hours uninterrupted sleep. Therefore, an employee could be paid for a minimum of 13 hours or a maximum of 21 hours for a 24-hour shift"
[p. 27, Dunlop and Associates, Inc.]

II. Support Personnel Wages--Dispatch, Clerical, Management

Assumptions: Dispatch employees can be utilized for some clerical work
 at the one-ambulance level
 \$2.00/hour wage for dispatchers for 40 hour/week
 1 week paid vacation
 1 week paid sick leave
 No overtime
 $24\text{-hour/day} \times 365\text{ days/year} = 8,760\text{ hours/year dispatch}$
 Requirements for support personnel follow this relation:
 $8,760\text{ hours} + 2,000(x-1) = \text{Total Hours Required}^*$ where
 x is the number of manned ambulances.

Calculations:

$$40\text{ hours} \times 50\text{ weeks/year} = 2,000\text{ hours/year/man}$$

$$\frac{8,760}{2,000}\text{ man-hours required} = 4.38\text{ men required}$$

One-manned ambulance cost:

$$\begin{aligned} 2,000\text{ hours/man/year} \times \$2.00/\text{hour} &= \$4,000/\text{man (salary)} \\ 80\text{ hours/man/year} \times \$2.00/\text{hour} &= \frac{160}{\$4,160/\text{man/year}} \text{ (vacation/sick leave)} \end{aligned}$$

$$4,160/\text{year} \times 4.38 = \$18,220\text{ cost of support personnel for entire system.}$$

Two-manned ambulance cost:

$$8,760\text{ hours} + 2,000\text{ hours} = 10,760\text{ hours required}$$

$$\frac{10,760}{2,000} = 5.38\text{ men required}$$

$$\begin{aligned} 2,000\text{ hours/man/year} \times \$2.00/\text{hour} &= \$4,000/\text{man (salary)} \\ 80\text{ hours/man/year} \times \$2.00/\text{hour} &= \frac{160}{\$4,160/\text{man/year}} \text{ (vacation/sick leave)} \end{aligned}$$

$$\$4,160/\text{man/year} \times 5.38\text{ men} = \$22,380\text{ cost of system.}$$

*This relationship is a compromise between the Dunlop and Associates relationship (e.g., total support hours required = $6,750(x)$ where x is the number of ambulances) and the relationship suggested by data from the California Ambulance Association.

III. Employee Benefits

Assumptions:

	<u>Percent of Gross Salary</u>	
	<u>D/A</u>	<u>Clerical</u>
Unemployment Insurance (California)	3.60	3.60
Workman's Compensation (California)	8.00	.58
Social Security Contribution (United States)	5.85	5.85
Medical and Hospital Insurance*	<u>5.00</u>	<u>5.00</u>
	22.45	15.03

*Dunlop and Associates, Inc., estimate.

IV. Vehicle and Equipment Depreciation

Assumptions:

	<u>Price</u>	<u>Capital Costs*</u> <u>Average</u> <u>Life</u>	<u>Salvage</u> <u>Value</u>
Standard van-type ambulance	\$13,500	5 years	\$3,375
Equipment on ambulance**	2,000	10 years	0
Equipment at each location***	5,000	10 years	500

*Estimates from the California Ambulance Association.

**List of equipment conforms to the legal requirements of the California Highway Patrol and U.S. Department of Transportation, National Highway Safety Administration, Vol. 11.

***Includes office, communication and personnel equipment (Dunlop and Associates, Inc., p. 72).

Calculation:

$$\text{Ambulance: } \frac{\$13,500 - \$3,375}{5} = \frac{10,125}{5} = \$2,025/\text{year}/\text{ambulance}$$

$$\text{Ambulance equipment: } \frac{2,000}{10} = 200/\text{year}/\text{ambulance}$$

$$\text{Equipment: } \frac{5,000 - 500}{10} = 450/\text{year}/\text{location}$$

V. Facility Operations and Maintenance

Assumptions: (From Dunlop and Associates, Inc., pp. 80-81)

Square footage required = 1,400 square feet + 500 square feet (x-1)

where x is the number of ambulances

Rent: \$2.00/square foot/year

Utilities: 25 percent of rent

Maintenance and supplies: 30 percent of rent

Phone*: \$1,235/manned ambulance

*Dunlop's figure of \$988/manned ambulance was increased 25 percent to allow for inflation.

VI. Insurance

	<u>CAA*</u>	<u>Dunlop**</u>
Basic liability/vehicle		145
Excess limits liability/vehicle (500,000 limit)	\$1,200	465
Malpractice liability/manned ambulance		
Business insurance (general liability fire insurance, equipment & building)	<u>204</u>	<u>04</u>
(17 percent of \$1,200 according to Dunlop)	\$1,404/vehicle	\$714/vehicle

*California Ambulance Association estimates.

**Dunlop and Associates, Inc.

VII. Other Fixed Costs

	Per ambulance	
	Dunlop*	Adjusted**
Advertising & promotion	680	850
Legal and accounting	400	500
Dues & subscriptions	70	88
Interest on capital investment	280	350 (850)***
Licenses****	70	300

*Dunlop and Associates, Inc., estimates, p. 82.

**Dunlop estimates adjusted for inflation by a factor of 1.25.

***Average annual value of capital investment multiplied by 7 percent.

****License costs were estimated through personal interview. California ambulances must have commercial tags; the cost is dependent on the weight and age of the vehicle.

VIII. Variable Ambulance Costs (cost/call)

Items included are ambulance repair, maintenance, and other miscellaneous costs.

Dunlop suggests an average figure of \$2.25/call. California Ambulance Association estimates this cost at approximately \$5.00/call.

This estimate is obviously dependent on the mileage/call as well as terrain, roads, and climatic conditions, and therefore, this figure is highly variable. A more precise estimate is a cost/mile figure. But such an estimate is also highly variable. The figure of \$4.00/call was used primarily to reflect inflation and the high mileage/call in rural areas.

IX. Other Variable Costs (cost/call)

Items include ambulance supplies, linens, uniforms, laundry, postage, stationery, and collection costs.

Dunlop estimated these charges as \$0.41/call for uniforms and linens and \$0.37/call for postage and stationery plus 40 percent of the variable ambulance costs of section VIII. Adjusting the per call figures for inflation (1.25 factor), gives approximately a new figure of \$1.00/call for postage and linens. The 40 percent estimate is not changed. CAA indicates that collection costs average nearly \$2.00/call.

Example #1: Cost/year of one-manned ambulance at one location*

Fixed Cost:	<u>Dollars</u>
Driver and attendant wages (Average of the 5 manning policies)	30,122
Support personnel	18,220
Benefits	
D/A (22.45% x 30,122)	6,762
Support personnel (15.03% x 18,220)	2,738
Depreciation (vehicles and equipment)	2,675
Facilities	
Rent (\$2.00/square foot x 1400 square feet)	2,800
Utilities (25% x \$2,800)	700
Maintenance and supplies (30% x \$2,800)	840
Telephone	1,235
Insurance (liability, malpractice and general)	1,404
Other fixed cost (advertising, legal, etc.)	2,588
Total Fixed Cost	<u>70,084</u>

Variable Cost (cost/call):

Ambulance repair, miscellaneous	\$ 6.00/call
Ambulance supplies, linens, uniforms, etc. (40% x \$5.00)	2.00/call
Postage, stationery	1.00/call
Collection costs	2.00/call
Total	<u>\$ 10.40/call**</u>

*Costs will vary from firm to firm due to:

- a) Manning policy for D/A,
- b) Combination of management, clerical, and dispatch personnel,
- c) Employee benefits,
- d) Facility rent and maintenance,
- e) The ambulance service area--size (square miles), population, roads, terrain, etc., which affect over-the-road costs,
- f) Size or number of capital purchases (e.g., discounts),
- g) many ambulance providers operate complementary businesses, e.g., medical supplies.

**Drew, T., S. Webb, D. Pearson, and J. Thompson, "Emergency Medical Services and the Hospital: A Statewide Analysis," *Hospital Administration*, Summer 1974, estimated the variable cost of a hospital-based ambulance system as \$14.48/call.

Example #2: Cost/year of two-manned ambulances at one location

Fixed Cost:	<u>Dollars</u>
Driver and attendant wages	60,244
Support personnel (\$4,160/man x 5.38 men)	22,380
Benefits	
D/A (\$60,244 x 22.45%)	13,524
Support personnel (\$22,380 x 15.03%)	3,364
Depreciation (vehicles and equipment)	4,900
Facilities:	
Rent (1900 square feet x \$2.00/square foot)	3,800
Utilities (25% x \$3,800)	950
Maintenance and supplies (30% x \$3,800)	1,140
Telephone	2,470
Insurance	2,808
Other fixed costs	<u>5,176</u>
Total Fixed Costs	120,756

Variable Costs (cost/call):

Same as in Example #1.

APPENDIX B

Resident Population Estimates by Demand Point

TABLE B-1--Resident Population Estimates by Demand Point

Demand point designation	Demand points listed by hospital service area (HSA)	Census county enumeration districts associated with each demand point	Estimated resident population in 1970	Number of ambulances in 1975
<u>Butte County</u>				
	Chico (HSA)			
4	Butte Meadows	12	378	0
5	Chico	19-30, 38-40, 41-62	40,193	7
6	Durham	63-65	3,096	0
9	Forest Ranch	13	278	0
11	Nord	33-36	534	0
15	Richardson Springs	31, 32, 37	2,955	0
23	Hamilton City (Glenn Co.)	5, 6, 11	<u>1,998</u>	<u>0</u>
	Total		49,432	7
<u>Paradise (HSA)</u>				
14	Paradise	1-11, 17, 18	14,598	5
17	Sterling City	14	<u>1,340</u>	<u>0</u>
	Total		15,938	5
<u>Oroville (HSA)</u>				
1	Bangor	98	490	0
2	Berry Creek	92, 94	423	0
7	Feather Falls	93	230	0
8	Forbestown	95	286	0
12	Oroville	66-91	21,060	3
13	Palerma	96, 97, 99, 100	5,270	0
16	Richvale	102, 103	628	0
18	Yankee Hill	16	<u>318</u>	<u>0</u>
	Total		28,705	3
<u>Gridley (HSA)</u>				
3	Biggs	101, 104, 105	2,084	0
10	Gridley	106-113	7,808	2
51	Live Oak (Sutter Co.)	1-7	<u>4,811</u>	<u>0</u>
	Total		14,703	2

continued on next page

TABLE B.-1 continued

Demand point designation	Demand points listed by hospital service area (HSA)	Census county enumeration districts associated with each demand point	Estimated resident population in 1970	Number of ambulances in 1975
	<u>Colusa County</u>			
	<u>Colusa (HSA)</u>			
19	Princeton	5	1,037	0
	<u>Glenn County</u>			
	<u>Willows (HSA)</u>			
20	Artois	19	592	0
21	Elk Creek	-	1,088	1
22	Glenn	18	1,231	0
24	Orland	1-4, 7, 9, 10	6,602	1
25	Willows	12-17, 20, 21	<u>6,010</u>	<u>0</u>
	Total		15,523	2
	<u>Shasta County</u>			
	<u>Redding (HSA)</u>			
28	Anderson	74, 78-91	14,164	0
29	Bella Vista	72	1,669	0
32	Cottonwood	92-94	2,574	0
33	Enterprise	56-60	11,486	0
35	Igo	96, 98	1,510	0
36	Lakehead	16, 17	599	0
38	Millville	11	606	0
39	Montgomery Creek	8, 9	897	0
40	Oak Run	10	1,313	0
42	Palo Cedro	74	362	0
43	Platina	97	113	0
44	Project City	18-21, 28	7,031	0
45	Redding	26, 29-55, 61-71, 73, 76, 77	21,181	7
46	Shingletown	12, 14	528	0
47	Summit City	27	700	0
48	Whiskeytown	95	907	0
49	Whitmore	13	<u>157</u>	<u>0</u>
	Total		71,797	7

continued on next page

TABLE B-1 continued

Demand point designation	Demand points listed by hospital service area (HSA)	Census county enumeration districts associated with each demand point	Estimated resident population in 1970	Number of ambulances in 1975
<u>Fall River Mills (HSA)</u>				
30	Burney	1, 2, 7	2,633	0
34	Fall River Mills	4, 5	1,393	1
37	McArthur	3	796	0
41	Old Station	6	651	0
27	Adin (Lassen County)	13	646	1
26	Bieber (Lassen County)	14	885	1
	Total		7,004	3
<u>Siskiyou County</u>				
<u>Mt. Shasta (HSA)</u>				
50	Dunsmuir	9, 10	2,819	3
31	Castella (Shasta Co.)	15	565	0
	Total		3,384	3
<u>Tehama County</u>				
<u>Red Bluff (HSA)</u>				
53	Gerber	11	713	0
54	Los Molinas	21, 24	3,315	0
55	Manton	1, 2	416	0
56	Mineral	3A	121	0
58	Paynes Creek	38	335	0
59	Proberta	16	1,571	0
60	Red Bluff	4-10, 13-15, 17, 19, 20, 22, 23	14,497	4
61	Tehama		317	0
	Total		21,285	4
<u>Corning HSA</u>				
52	Corning	27-33	6,508	1
57	Paskenta	18	605	0
62	Vina	25, 26	1,119	0
	Total		8,232	1

TABLE B-1 continued

Demand point designation	Demand points listed by hospital service area (HSA)	Census county enumeration districts associated with each demand point	Estimated resident population in 1970	Number of ambulances in 1975
<u>Trinity County</u>				
<u>Weaverville (HSA)</u>				
63	Big Bar	8	334	0
64	Burnt Ranch	9	685	0
65	Douglas City	6	489	0
66	Forest Glen	13	229	0
67	Hayfork	10, 12	1,493	1
68	Hyampon	11	552	0
69	Junction City	7	425	0
70	Lewiston	3, 5	1,040	0
71	Trinity Center	4	286	0
72	Weaverville	1, 2	<u>1,489</u>	<u>2</u>
Total			7,022	3
TOTAL - STUDY AREA			244,062	40

Source: U.S. Bureau of the Census, 1972 and California Department of Transportation, Division of Highways, 1971.

APPENDIX C

Population-Day Estimates

In this appendix section estimates are made for the total number of "population-days" (12 hours) spent in the study area by residents and nonresidents. Three groups are involved: local residents, visitors to the area's recreation sites, and transients passing through on the area's highways. This section explains how estimates of visitor-days, transient-days, and resident-days were made and how they were adjusted to a similar basis allowing their aggregation for a total population-day estimate. Both visitor-days and transient-days had to be adjusted downward to allow for residents visiting recreation sites and using the area's highways, to avoid double counting when added to the resident-day totals. These population-day estimates should prove broadly useful to planners of any delivery service in the study area.

Derivation of Visitor-Day Estimates

Data from several sources were gathered and adjusted in order to be combined into a visitor-day measure. Visits to the area's national forests, state parks, national parks, Pacific Gas and Electric Sites, and state wildlife areas and fish hatcheries are counted by the U.S. Forest Service, The California State Parks and Recreation Department, U.S. National Park Service, Pacific Gas and Electric Company, and The California Department of Fish and Game.

U.S. Forest Service Data

The federal government owns over one-third of the land in the study area; the majority of the federally-owned land is administered by the U.S. Forest Service. The study area includes parts of the Lassen, Mendocino, Shasta, Six Rivers, Trinity, and Plumas National Forests. The U.S. Forest Service (1972) records recreation use by various geographical delineations: counties, forests, and ranger districts. Ranger districts are the smallest areas within a National Forest for which visitor-day data are available. Visitor-days are associated with a particular ranger district in a rather arbitrary manner. No other data, however, are available to locate on a more rational basis the people involved in outdoor recreation activities. In some instances, visitor-days for a particular ranger district are divided between two or three demand points due to the proximity of the district to several demand points.

Although specific data are not available by month, U.S. Forest personnel are aware of the peak usage months during the year [personal interview, 1974]. In general, recreation use in the U.S. forests is minimal during the winter months, with activity slowly increasing to Memorial Day. Recreation use then normally declines slightly until a few days before July 4th. Peak usage occurs between July 4th and Labor Day. Usage then gradually declines until October 1st, when activity again becomes minimal.

Service data estimates of monthly recreation use in the U.S. forests were assumed to follow the same monthly percentage distribution as the attendance at the Whiskeytown National Recreation Area (NRA) because

detailed data are available on a monthly basis and the use pattern there appeared representative of recreation use in Northern California. For those recreation sites where the Whiskeytown NRA attendance distribution was not appropriate because of significant amounts of skiing and hunting, adjustments in the percentages were made. Appendix Table C-1 shows the monthly distribution pattern in the Whiskeytown NRA, the adjusted distribution in several ranger districts where hunting is popular, and the Pacific Gas and Electric campground monthly distribution. The allocation of U.S. Forest visitor-days among demand points by forest and by ranger district is given in Appendix Table C-2.

California State Parks and Recreation Data

In state parks the count is by visitor-days. Each visitor is assumed to spend 12 hours at the recreation site; an overnight visitor, an additional 12 hours; so a visitor-day equals 12 hours. To put these data on a monthly basis, the following conversion was made:

Total number of visitor-days per month =

(No. visitors per month) (visitor-days per visitor) +
(No. overnights per month) (visitor-days per overnight)

U.S. National Park Service

A similar computation was made to put visitor-days in the national parks on a monthly basis:

Total number of visitor-days per month =

(No. visitors per month) (visitor-days per visitor) +
(No. overnights per month) (visitor-days per overnight)

TABLE C-1--Adjusted Distribution for Almanor, Glenn County, and Corning
Ranger Districts and P.G.&E. Campgrounds

District	Total	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		percent											
<u>General</u>													
Monthly distribution in Whiskeytown NRA	100.0	1.8	2.4	4.3	5.1	9.5	14.9	19.7	21.1	11.8	5.1	2.8	1.5
<u>Adjusted distribution</u>													
Almanor R.D. <u>a/</u>	100.0	1.8	2.4	4.3	5.1	9.5	14.9	19.2	20.6	11.8	5.1	3.8	1.5
Glenn County <u>b/</u>	100.0	1.8	2.4	4.3	5.1	9.5	14.9	17.7	21.1	13.8	5.1	3.8	1.5
Corning R.D. <u>b/</u>	100.0	1.8	2.4	4.3	5.1	9.5	9.9	14.7	22.1	20.8	5.1	4.8	1.5
P.G.&E. Campgrounds	100.0	0	0	0	6.1	10.5	15.9	22.7	24.1	14.6	6.1	0	0

a/ Adjusted for large influx of hunters during November.

b/ Adjusted for large influx of hunters during September.

General use distribution is similar to that of Whiskeytown NRA.

TABLE C-2--Allocation of U.S. Forest Visitor-Days Among Demand Points by Forest and Ranger District.

<u>Forest</u>	<u>Demand Point</u>
Mendocino Forest	
Glenn County (total)	Elk Creek
Tehama County	
1/2 Corning R.D.	Paskenta
Six Rivers Forest	
Trinity County	
Mad River R.D.	Forest Glen
Trinity Forest	
Shasta County	
1/2 Yolla-Bolla R.D.	Platina
Tehama County	
1/2 Yolla-Bolla R.D.	Paskenta
Trinity County	
1/3 Big Bar R.D.	Big Bar
1/3 Big Bar R.D.	Burnt Ranch
1/3 Big Bar R.D.	Junction City
3/4 Hayfork R.D.	Hayfork
1/4 Hayfork R.D.	Hyampom
Coffee Creek R.D.	Trinity Center
1/2 Weaverville R.D.	Weaverville
1/2 Weaverville R.D.	Lewiston
Shasta Forest	
Shasta County	
1/2 Lake Shasta R.D.	Lakehead
1/2 Lake Shasta R.D.	Project City
Lassen Forest	
Shasta County	
Hat Creek R.D.	Old Station
Tehama County	
Mineral R.D.	Mineral
Butte County	
1/4 Almanor R.D.	Butte Meadows
Plumas Forest	
Butte County	
1/2 Oroville R.D.	Feather Falls
1/4 Oroville R.D.	Yankee Hill
1/4 Oroville R.D.	Berry Creek

Pacific Gas and Electric Data

P.G. & E. reports use statistics in terms of occupancy-days. According to P.G. & E. personnel, one occupancy-day is equivalent to 1.42 visitor-days as defined by the U.S. Forest Service. The monthly percentage attendance at P.G. & E. campgrounds, which are open only from April through October, were given earlier in Appendix Table C-1.

California Department of Fish and Game

The Fish and Game Department reports monthly attendance in terms of use-days--one person performing one activity for 24 hours. Due to the nature of the counting system, a person performing more than one activity (e.g., camping and boating) during one day may account for more than one use-day. Since the preceding data sources define visitor-days in terms of a 12-hour period with little or no double counting possible, it was decided to count each use-day as equivalent to one visitor-day.

Derivation of Transient-Day Estimates

The California Department of Transportation, Division of Highways, samples the traffic flow at a sufficient number of intervals on all state highways to indicate the general pattern of traffic flow on an average daily basis. By assuming an average speed between counting stations, the average length of time a vehicle is in the vicinity of a counting station can be determined. The time dimension and average daily traffic flow is converted to an estimate of transient population for a specific site on a monthly basis as follows:

Transient-days per month = (Average No. vehicles per day)
 (30 days per month) (2.4 transients per vehicle) (No.
 hours in vicinity)
 (one transient-day per 12 transient-hours).

The highways which were included in the count of transient vehicles are shown in Appendix Table C-3 in which the estimated number of hours each vehicle was in the vicinity of the counting station for each route is indicated.

TABLE C-3--Highways Used to Calculate Transient Population and the Number of Hours Each Vehicle Was Near a Counting Station on Each Route

Route 3	.5 hours
Route 5	.25 hours
Route 20	.25 hours
Route 32	.25 hours
Forest Ranch, Butte Meadows	.5 hours
Route 36	.5 hours
Route 44	.25 hours
Route 65	.25 hours
Route 70	.25 hours
Yankee Hill	.5 hours
Route 89	.5 hours
Route 99	.25 hours
Route 113	.25 hours
Route 299	.4 hours

Adjustments to Visitor-Days and Transient-Days Estimates

As mentioned earlier, adjustments had to be made in both the visitor-day and the transient-day monthly totals to allow for residents who visit recreation sites and who use the highways but who are already counted among the resident population.

Use of the recreation sites by residents is estimated by origin-of-visitor data. Two sources of data are available for Northern California. One is the P.G. & E. visitor attendance reports which reveal the origin of all registered campers in each of their campgrounds [Pacific Gas and Electric, 1972]. For 1972, the P.G. & E. campgrounds of North Shore, Cassel, and Macumber reported that 23 percent, 16 percent, and 40 percent, respectively, of the total number of visitors originated from within the study area. The second source is U.S. Forest Service data on visitors to the Wilderness Areas. The Salmon-Trinity, Yolla-Bolla, and 1,000 Lakes wilderness areas reported that 14 percent, 7.3 percent, and 31.4 percent, respectively, of the total attendance were from the study area [U.S. Forest Service, 1972]. In addition, the U.S. Forest Service, during 1971-72, conducted skier point studies for the Mt. Lassen and Mt. Shasta ski areas. These studies revealed that 70.6 percent and 79 percent of the skiers at Mt. Shasta and Mt. Lassen, respectively, came from the area.

In spite of this information, it is virtually impossible to adjust each recreation site population accurately for resident visitors. The number of visitor-days at each recreation site, therefore, was arbitrarily reduced by 25 percent.

The adjustments to the transient population for resident use of state highways also required several stringent assumptions. Traffic flow on most major highways exhibits an annual pattern of high summer use, with the peak during August, and low use during the winter, with January the low usage month. In order to isolate only the transient traffic flow, it

was assumed that the monthly local resident traffic could be approximated by the January traffic flow estimate. Accordingly, the January traffic figure was subtracted from all the remaining monthly estimates. For highways with high transient use during the entire year, the figures will be somewhat low (Highways 99 and 20). For highways which exhibit high summer usage, the figures are realistic. Highways 3, 5, 36, 44, 70, 89, and 299 exhibit high variance in usage throughout the year.

Further adjustments in transient-days were also necessary. Data on traffic flow at a particular site are given both in terms of average annual daily traffic (AADT) and average daily traffic for the peak month. To extrapolate this information into monthly estimates of transient population, some relationships from the California Department of Transportation were used:

$$V_i = A(1.0 + R \cdot I_i) \quad i = \text{particular month} = 1, 2, \dots, 12$$

$$V_i = \text{average daily traffic for month } i$$

$$A = \text{average daily traffic for 1970 (AADT)}$$

$$R = \text{annual variance factor} = \frac{\sum \text{summer months traffic} - \sum \text{winter months}}{(6) (\text{AADT})}$$

$$I_i = \text{the degree of shift in the } R \text{ factor peculiar to each month, } i.$$

Appendix Table C-4 gives the I factors for each month of the year.

The I factors are explained as follows [California Department of Transportation, 1971, p. 7]:

The curve pattern formed by annual fluctuation between summer and winter traffic volume is generally consistent from one place to another to the extent that the volume for each month of the year tends to retain its position in the pattern relative to those of all other months, but varies in its departure for AADT as the R factor varies. Each unit of change in the R factor (expressed in hundredths) is accompanied by a

TABLE C-4--I Factors for Each Month

Month	Factor
January	-.56
February	-.55
March	-.49
April	-.44
May	-.20
June	.35
July	1.08
August	1.20
September	.62
October	-.08
November	-.45
December	-.51

Source: California Department of Transportation,
Division of Highways, unpublished data
manual, December 1971.

corresponding shift in the position that each month bears in relation to AADT. The degree of shift per unit of R factor is a constant value peculiar to each month termed the I (increment) factor.

As noted above, the information available at each counting station or demand point consists of the AADT and the average daily traffic for the peak usage month. By assuming the peak month of traffic flow is August and that the minimum traffic flow or local commute traffic is approximated by the January traffic flow, the number of transient vehicles can be estimated for each demand point on a monthly basis. The calculation for a particular point for month i is as follows:

$$V_{AUG} = A(1.0 + RI_{AUG})$$

$$P = \frac{V_{AUG} - A}{AI_{AUG}}$$

$$\text{Average number transient vehicles (month i)} = V_i - V_{JAN}$$

$$= A(1.0 + RI_i) - A(1.0 + RI_{JAN})$$

$$= ARI_i - ARI_{JAN}$$

$$= AR(I_i - I_{JAN})$$

(Substitute R from above)

$$= \frac{(V_{AUG} - A)}{I_{AUG}} (I_i - I_{JAN})$$

$$= \frac{I_i - I_{JAN}}{I_{AUG}} (V_{AUG} - A)$$

For example, the number of transient vehicles for a particular site for the month of February is found as follows:

$$\begin{aligned} \text{Average number transient vehicles (FEB)} &= \frac{-.55 - (.56)}{1.2} (V_{AUG} - A) \\ &= .008 (V_{AUG} - A) \end{aligned}$$

Resident-Day Estimates

Although the resident population of the demand points is known fairly accurately from the census, adjustments had to be made in the totals so that they could be added to the visitor-day and transient-day adjusted monthly estimates. All three populations must be put on a time basis. It was not only the number of people who visited recreation sites that was counted but also the time each person spent at the site. For transients, it was not the number passing through, but time spent in the area. Similarly the resident population count must be put on a time basis. The following conversion was made:

No. resident-days per month =

$$(\text{No. residents}) (24 \text{ hours per day}) \left(\frac{1 \text{ resident-day}}{12 \text{ resident-hours}} \right) (30 \text{ days per month})$$

Population-Day Estimates

The monthly estimates of 12 hour population-days by demand points in the study area are presented in Appendix Table C-5. Population-day estimates represent the sum of visitor-days, transient-days, and resident-days which have incorporated all the adjustments discussed above.

TABLE C-5--Estimates of Population-days (P-D), Visitor-days (V-D), Transient-days (T-D) and Resident-days (R-D) by Demand Point and by Month of the Year (1972) for the Hospital Service Areas in the Study area (in 1,000's)

	Total	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
<u>Butte Co.</u>													
Chico (H.S.A.)													
Butte Meadows (R-D)	272.2	22.7	a/						22.7	a/			
Lassen Forest (V-D)	44.2	.8	1.1	1.9	2.3	4.2	6.4	8.5	9.3	5.2	2.3	.7	.7
Rte 32 (T-D)	9.9	0	A	.1	.2	.5	1.3	2.3	2.5	2.0	.7	.2	.1
Total	326.3								34.5				
Chico (R-D)	28,939.0	2,411.6							2,411.6				
Bidwell Mansion S.P. (V-D)	31.5	2.0	2.6	2.2	2.2	3.5	2.0	2.3	2.5	1.8	7.8	1.4	1.3
Rte 99 (T-D)	40.8	0	.1	.4	.7	2.1	5.5	9.7	10.3	8.3	2.8	.6	.3
Total	29,011.3								2,424.4				
Durham (R-D)	2,229.1	185.8							185.8				
Forest Ranch (R-D)	200.2	16.7							16.7				
Rte 32 (T-D)	10.9	0	A	.1	.2	.6	1.5	2.6	2.8	2.2	.8	.2	.1
Total	211.1								19.5				
Nord (R-D)	384.5	32.0							32.0				
Richardson Springs (R-D)	2,127.6	177.3							177.3				
*Hamilton City (R-D)	1,438.6	119.9							119.9				
Rte 32 (T-D)	5.2	0	A	A	.1	.3	.7	1.2	1.3	1.1	.4	.1	A
Total	1,443.8								121.2				
Grand Total (P-D)	35,733.7								2,994.7				
<u>Oroville (H.S.A.)</u>													
Bangor (R-D)	352.8	29.4							29.4				
Berry Creek (R-D)	304.6	25.4							25.4				
Plumas Forest (V-D)	51.2	.9	1.2	2.2	2.6	4.9	7.6	10.1	10.8	6.0	2.6	1.4	.8
Total	355.8								36.2				
Feather Falls (R-D)	165.6	13.8							13.8				
Plumas Forest (V-D)	102.5	1.8	2.5	4.4	5.2	9.7	15.3	20.2	21.6	12.1	5.2	2.9	1.6
Total	268.0								35.4				
Forbestown (R-D)	206.0	17.2							17.2				
Oroville (R-D)	15,163.2	1,263.6							1,263.6				
Lake Oroville SRA (V-D)	416.3	10.3	15.6	24.0	34.8	60.6	61.1	63.3	57.2	39.7	22.7	19.3	7.9
Lake Oroville Overlook (V-D)	157.3	6.6	7.8	11.5	15.8	24.4	16.9	18.0	18.2	15.1	10.7	7.0	5.3
Oroville Wildlife & Recreation Area (V-D)	33.3	1.7	2.1	2.8	3.0	4.2	3.4	3.3	2.4	3.1	3.0	2.6	1.7
Feather River Fish Hatchery (V-D)	99.5	1.8	1.5	8.3	10.4	12.0	8.2	5.9	10.0	11.6	13.4	11.3	5.0
Rte 70 (T-D)	18.3	0	A	.2	.3	.9	2.5	4.3	4.6	3.7	1.3	.3	.1
Total	15,887.9								1,356.1				
Palermo (R-D)	3,794.4	316.2							316.2				
Richvale (R-D)	452.2	37.7							37.7				
Yankee Hill (R-D)	229.0	19.1							19.1				
Plumas Forest (V-D)	51.2	.9	1.2	2.2	2.6	4.9	7.6	10.1	10.8	6.0	2.6	1.4	.8
Rte 70	10.3	0	A	.1	.2	.5	1.4	2.5	2.6	2.0	.7	.2	.1
Total	290.5								32.5				
GRAND TOTAL (P-D)	21,607.6								1,984.0				

Table C-5 (continued)

	Total	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Paradise (H.S.A.)													
Paradise (R-D)	10,510.6	875.9							875.9				
Sterling City (R-D)	964.8	80.4							80.4				
Grand Total	11,475.4								956.3				
Gridley (H.S.A.)													
Biggs (R-D)	1,500.5	125.0							125.0				
Gridley (R-D)	5,621.8	468.5							468.5				
Grey Lodge Wildlife Area (V-D)	28.7	4.3	2.3	1.9	1.5	.8	1.5	1.5	1.1	1.6	2.0	5.4	4.7
Rte 99 (T-D)	20.9	0	A	.2	.4	1.1	2.8	4.9	5.3	4.2	1.4	.3	.2
Total	5,671.4								474.9				
Live Oak (R-D)	3,463.9	288.7							288.7				
Rte 99 (T-D)	20.9	0	A	.2	.4	1.1	2.8	4.9	5.3	4.2	1.4	.3	.2
Total	3,484.8								293.9				
Grand Total (P-D)	10,665.7								893.9				
Glenn Co.													
Willows (H.S.A.)													
Artois (R-D)	426.2	35.5							35.5				
Elk Creek (R-D)	783.4	65.3							65.3				
Mendocino Forest (V-D)	32.6	.6	.8	1.4	1.7	3.1	4.9	5.8	6.9	4.5	1.7	.9	.5
Total	816.0								72.2				
Glenn (R-D)	886.3	73.9							73.9				
Rte 45 (T-D)	3.0	0	A	A	.1	.2	.4	.7	.8	.6	.2	A	A
Total	889.3								74.7				
Orland (R-D)	4,753.4	396.1							396.1				
Rte 5 (T-D)	22.6	0	A	.2	.4	1.2	3.0	5.3	5.7	4.6	1.6	.4	.2
Total	4,776.0								401.8				
Willows (R-D)	4,327.2	360.6							360.6				
Sacramento National Wildlife													
Refuge (V-D)	5.2	1.4	.1	.3	A	A	A	A	A	.1	.3	1.4	1.4
Rte 5 (T-D)	46.1	0	.1	.5	.8	2.4	6.2	10.9	11.7	9.4	3.2	.7	.3
Total	4,378.5								372.3				
Grand Total (P-D)	11,286.0								956.4				
Shasta Co.													
Redding (H.S.A.)													
Anderson (R-D)	10,198.1	849.8							849.8				
Rte 5 (T-D)	47.8	0	.1	.5	.8	2.5	6.4	11.3	12.1	9.7	3.3	.7	.3
Total	10,245.9								861.9				
Bella Vista (R-D)	1,201.7	100.1							100.1				
Rte 299 (T-D)	2.1	0	A	A	A	.1	.2	.4	.7	.3	.1	A	A
Total	1,203.8								100.8				
Cottonwood (R-D)	1,853.3	154.4							154.4				
Rte 5 (T-D)	47.8	0	.1	.5	.8	2.5	6.4	11.3	12.1	9.7	3.3	.7	.3
Total	1,901.1								166.5				

Table C-5 (continued)

	Total	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Shasta Co.													
Redding (H.S.A.)													
Enterprise (R-D)	8,269.9	689.2							689.2				
Igo (R-D)	1,087.2	90.6							90.6				
Lakehead (R-D)	431.3	35.9							35.9				
Shasta N.R.A. (V-D)	865.2	15.6	20.8	37.2	44.1	82.2	128.9	170.4	182.5	102.1	44.1	24.2	13.0
Rte 5 (T-D)	22.4	0	A	.2	.3	1.0	2.7	4.7	5.0	4.0	3.8	.3	.1
Total	1,318.9								223.4				
Millville (R-D)	436.3	36.4							36.4				
Rte 44 (T-D)	6.1	0	A	.1	.1	.3	.8	1.4	1.5	1.2	.4	.1	A
Total	442.4								37.9				
Montgomery Creek (R-D)	645.8	53.8							53.8				
Rte 299 (T-D)	7.9	0	A	.1	.1	.3	.5	1.5	1.6	1.3	.4	2.0	A
Total	653.7								55.4				
Oak Run (R-D)	945.4	78.8							78.8				
Platina (R-D)	81.4	6.8							6.8				
Trinity Forest (V-D)	69.1	1.2	1.7	3.0	3.5	6.6	10.3	13.6	14.6	8.2	3.5	1.9	1.0
Rte 36 (T-D)	2.9	0	A	A	.1	.2	.4	.7	.7	.6	.2	A	A
Total	153.4								22.1				
Project City (R-D)	5,062.3	421.8							421.9				
Shasta N.R.A. (V-D)	865.2	15.6	20.8	37.2	44.1	82.2	128.9	170.4	182.5	102.1	44.1	24.2	13.0
Rte 5 (T-D)	41.7	0	.1	.4	.7	2.2	5.6	9.9	10.6	8.5	2.9	.6	.3
Total	5,969.2								614.9				
Redding (R-D)	19,570.3	1,630.8							1,630.8				
Shasta State Historical													
Park (V-D)	27.3	1.0	1.3	1.9	1.8	2.8	3.4	4.0	4.7	2.8	1.8	1.1	.8
Rte 5 (T-D)	47.8	0	.1	.5	.8	2.5	6.4	11.3	12.1	9.7	3.3	.7	.3
Total	19,645.4								1,647.7				
Shingletown (R-D)	423.4	35.3							35.3				
McCumber (PG&E) (V-D)	3.3	0	0	0	.2	.3	.5	.7	.8	.5	.2	0	0
Rte 44 (T-D)	5.2	0	A	.1	.1	.3	.7	1.2	1.3	1.1	.4	.1	A
Total	431.9								37.4				
Summit City (R-D)	504.0	42.0							42.0				
Whiskeytown (R-D)	653.0	54.4							54.4				
Whiskeytown N.P. (V-D)	752.9	13.9	18.4	32.2	38.1	71.3	111.8	148.0	158.9	88.8	38.1	21.1	12.3
Rte 299 (T-D)	14.6	0	A	.1	.3	.8	2.0	3.4	3.7	3.0	1.0	.2	.1
Total	1,420.5								217.0				
Whitmore (R-D)	113.0	9.4							9.4				
Palo Cedro (R-D)	260.6	21.7							21.7				
Rte 44 (T-D)	13.9	0	A	.1	.2	.7	1.9	3.3	3.5	2.8	1.0	.2	.1
Total	274.5								25.2				
Grand Total (P-D)	54,580.2								4,920.2				

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Table C-5 (continued)

	Total	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
<u>Shasta Co.</u>													
Fall River Mills (H.S.A.)													
*Adin (R-D)	465.1	38.8							38.8				
Rte 299 (T-D)	4.2	0	A	A	.1	.2	.6	1.0	1.1	.8	.3	.1	A
Total	469.3								39.8				
*Bieber (R-D)	637.2	53.1							53.1				
Rte 299 (T-D)	4.2	0	A	A	.1	.2	.6	1.0	1.1	.8	.3	.1	A
Total	641.4								54.2				
Burney (R-D)	1,895.8	158.0							158.0				
McArthur-Burney Falls (S.P.) (V-D)	179.9	.8	.8	3.0	5.1	12.8	31.0	46.6	45.6	25.1	6.3	1.7	1.2
North Shore P.G.&E (V-D)	7.8	0	0	0	.5	.8	1.2	1.8	1.9	1.1	.5	0	0
Rte 299 (T-D)	23.6	0	A	.2	.4	1.2	3.2	5.6	6.0	4.8	1.6	.4	.2
Total	2,107.1								211.5				
Fall River Mills (R-D)	1,003.0	83.6							83.6				
Crystal Lake Fish Hatchery (V-D)	13.7	.4	.5	.9	1.4	1.3	1.2	1.9	2.6	1.7	1.0	.6	.3
Cassel (P.G.&E) (V-D)	4.1	0	0	0	.2	.4	.6	.9	.1	.6	.7	.1	.1
Rte 299 (T-D)	9.7	0	A	.1	.2	.5	1.3	2.3	2.5	2.0	.7	.1	.1
Total	1,030.5								88.8				
McArthur (R-D)	573.1	47.8							47.8				
Rte 299 (T-D)	9.0	0	A	.1	.2	.5	1.2	2.1	2.3	1.8	.6	.1	.1
Total	582.1								50.0				
Old Station (R-D)	468.7	39.1							39.1				
Lassen Forest (V-D)	168.7	3.0	4.0	7.3	8.6	16.0	25.1	33.2	35.6	19.9	8.6	4.7	2.5
Rte 89 (T-D)	9.5	0	A	.1	.2	.5	1.2	2.3	2.4	1.9	.7	.1	.1
Total	646.9								77.0				
Grand Total (P-D)	5,477.3								522.2				
<u>Siskiyou Co.</u>													
Mt. Shasta (H.S.A.)													
Dunsmuir (R-D)	2,029.7	169.1							169.1				
Rte 5 (T-D)	50.4	0	.1	.5	.9	2.6	6.8	11.9	12.8	10.3	3.5	.8	.4
Total	2,080.1								181.9				
Castella (R-D)	406.8	33.9							33.9				
Castle Crags S.P. (V-D)	61.6	.2	.3	1.3	2.1	4.7	10.3	14.8	15.6	9.0	2.2	.7	.3
Rte 5 (T-D)	43.5	0	.1	.4	.8	2.2	5.9	10.3	11.0	8.9	3.0	.7	.3
Total	511.9								60.5				
<u>Tehama Co.</u>													
Red Bluff (H.S.A.)													
Gerber (R-D)	513.4	42.8							42.8				
Los Molinos (R-D)	2,386.8	198.9							198.9				
Rte 99 (T-D)	9.6	0	A	.1	.2	.5	1.3	2.3	2.4	1.9	.7	.1	.1
Total	2,396.4								201.3				
Mineral (R-D)	87.1	7.3							7.3				
Lassen Park (V-D)	494.7	9.3	8.0	6.0	3.9	19.8	60.2	122.3	141.4	86.9	22.9	5.9	8.0
Lassen Forest (V-D)	241.0	4.3	5.8	10.4	12.3	22.9	35.9	47.2	50.9	28.5	12.3	6.8	3.6
Rte 36 (T-D)	10.4	0	A	.1	.2	.5	1.4	2.5	2.6	2.1	.7	.2	.1
Total	833.2								202.2				

Table C-5 (continued)

	Total	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
<u>Tehama Co.</u>													
Red Bluff (H.S.A.)													
Paynes Creek (R-D)	241.2	20.1							20.1				
Darrah Springs Fish Hatchery (V-D)	1.8	.1	.1	.2	.2	.2	.2	.3	.2	.2	.1	A	A
Tehama Wildlife Mgt. Area (V-D)	17.5	.8	1.5	.8	2.8	1.3	.2	.2	.2	.5	8.2	.5	.4
Rte 36 (T-D)	10.4	0	A	.1	.2	.5	1.4	2.5	2.6	2.1	.7	.2	.1
Total	270.8								23.1				
Red Bluff (R-D)	10,437.8	869.8							869.8				
William Ide Abode SHP (V-D)	30.0	1.0	1.2	2.0	2.2	3.4	3.9	4.4	4.0	4.1	2.3	.8	.5
Rte 5 (T-D)	36.5	0	A	.4	.6	1.9	4.9	8.6	9.2	7.4	2.5	.6	.3
Total	10,504.3								883.1				
Proberta (R-D)	1,131.1	94.3							94.3				
Tehama (R-D)	228.2	19.0							19.0				
Manton (R-D)	299.5	25.0							25.0				
Grand Total (P-D)	16,176.9								1,490.8				
<u>Corning (H.S.A.)</u>													
Corning (R-D)	4,685.8	390.5							390.5				
Woodson Bridge SRA (V-D)	55.9	.9	1.8	2.0	3.2	6.1	8.5	10.7	10.1	6.8	2.9	1.3	.7
Rte 5 (T-D)	31.9	0	A	.4	.6	1.8	4.8	8.4	9.0	3.5	2.5	.5	.3
Total	4,773.3								409.6				
Paskenta (R-D)	435.6	36.3							36.3				
Trinity Forest (V-D)	69.1	1.2	1.6	3.0	3.5	6.6	10.3	13.6	14.6	8.2	3.5	1.9	1.0
Mendocino Forest (V-D)	20.3	.4	.5	.6	1.0	2.0	2.0	3.0	4.6	4.3	1.0	.6	.3
Total	525.0								55.4				
Vina (R-D)	805.7	67.2							67.2				
Rte 99 (T-D)	8.2	0	A	.1	.1	.5	1.2	2.1	2.2	1.8	.6	.1	.1
Total	814.4								69.3				
Grand Total (P-D)	6,112.7								534.4				
<u>Colusa Co.</u>													
Princeton (R-D)	746.6	62.2							62.2				
Rte 45 (T-D)	4.3	0	A	A	.1	.2	.6	1.0	1.1	.9	.3	.1	A
Total	750.9								63.3				
<u>Trinity Co.</u>													
Weaverville (H.S.A.)													
Big Bar (R-D)	240.5	20.0							20.0				
Trinity Forest (V-D)	105.2	1.9	2.5	4.5	5.4	10.0	15.7	20.7	22.2	12.4	5.4	2.9	1.6
Rte 299 (T-D)	8.6	0	A	A	.1	.4	1.1	2.0	2.1	1.7	.6	.4	.1
Total	354.3								44.3				
Burnt Ranch (R-D)	493.2	41.1							41.1				
Trinity Forest (V-D)	105.2	1.9	2.5	4.5	5.4	10.0	15.7	20.7	22.2	12.4	5.4	2.9	1.6
Rte 299 (T-D)	11.8	0	A	.1	.2	.6	1.6	2.8	3.0	2.4	.8	.2	.1
Total	610.2								66.3				

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Table C-5 (continued)

	Total	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Trinity Co.													
Weaverville (H.S.A.)													
Douglas City (R-D)	352.1	29.3							29.3				
Rte 299 (T-D)	10.4	0	A	.1	.2	.6	1.4	2.5	2.6	2.1	.7	.2	.1
Total	362.5								32.0				
Forest Glen (R-D)	164.9	13.7							13.7				
Six Rivers Forest (V-D)	21.2	.4	.5	.9	1.0	2.0	3.2	4.2	4.5	2.5	1.1	.6	.3
Rte 36 (T-D)	1.7	0	A	A	A	.1	.2	.4	.4	.4	.1	A	A
Total	187.8								18.7				
Hyampom (R-D)	397.4	33.1							33.1				
Trinity Forest (V-D)	14.4	.3	.3	.6	.7	1.4	2.1	2.8	3.0	1.7	.7	.4	.2
Total	411.8								36.2				
Junction City (R-D)	306.0	25.5							25.5				
Trinity Forest (V-D)	105.2	1.9	2.5	4.5	5.4	10.0	15.7	20.7	22.2	12.4	5.4	2.9	1.6
Rte 299 (T-D)	6.2	0	A	.1	.1	.3	.8	1.5	1.6	1.2	.4	.1	A
Total	417.4								49.3				
Hayfork (R-D)	1,075.0	89.6							89.6				
Trinity Forest (V-D)	43.1	.8	1.0	1.9	2.2	4.1	6.4	8.3	9.1	5.1	2.2	1.2	.6
Rte 3 (T-D)	14.8	0	A	.1	.3	.8	2.0	3.5	3.7	3.0	1.0	.2	.1
Total	1,132.9								102.4				
Lewiston (R-D)	748.8	62.4							62.4				
Trinity Forest (V-D)	168.8	3.0	4.1	7.3	8.6	16.0	25.2	33.3	35.6	19.9	8.6	4.7	2.5
Trinity River Fish Hatchery (V-D)	17.2	.1	.4	.6	.6	1.8	1.9	2.7	3.5	3.5	1.4	.4	.1
Total	934.8								101.6				
Trinity Center (R-D)	205.9	17.2							17.2				
Trinity Forest (V-D)	104.9	1.9	2.5	4.5	5.4	10.0	15.6	20.7	22.1	12.4	5.4	2.9	1.6
Rte 3 (T-D)	2.9	0	A	A	.1	.2	.4	.7	.7	.6	.2	A	A
Total	313.7								40.0				
Weaverville (R-D)	1,072.1	89.3							89.3				
Weaverville Joss House SHP (V-D)	26.9	.4	.6	1.3	1.3	2.3	3.2	4.6	5.6	3.7	1.9	1.1	.8
Trinity Forest (V-D)	168.8	3.0	4.1	7.3	8.6	16.0	25.2	33.3	35.6	19.9	8.6	4.7	2.5
Rte 299 (T-D)	18.0	0	A	.2	.3	.9	2.4	4.3	4.6	3.7	1.2	.3	.1
Total	1,285.8								135.1				
Grand Total (P-D)	6,011.2								625.9				

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* Demand points located in an adjoining county.

A = less than 50 visitor-days or transient-days.

R-D = Resident-days; V-D = Visitor-days; T-D = Transient-days; P-D = Population-days (V-D's + R-D's + T-D's).

NOTE: Total may not equal sum because of rounding.

Sources: U.S. Forest Data: U.S. Forest Service, unpublished Recreation-Use Information, Administrative Unit Summary: Ranger District Regional Forester, California, CY 1972. California State Parks and Recreation Data: California, The Resources Agency, Department of Parks and Recreation, Management Reports, unpublished monthly data, FY 1971-72, 1972-73. National Park Data: U.S. Department of the Interior, National Park Service, Public Use of the National Parks, CY (monthly) 1972. National Wildlife Refuge Data: U.S. Department of the Interior, Fish and Wildlife Service, Public Use Report, unpublished data, CY (monthly) 1972. California State Wildlife Areas and Fish Hatchery Data: California, The Resources Agency, Department of Fish and Game, Public Recreation Use on State Owned or Operated Areas, unpublished monthly data, FY 1971-72, 1972-73. Pacific Gas & Electric Co., unpublished Campground Attendance Data, San Francisco, 1972.

Transient Data: California, Business and Transportation Agency, Division of Highways, 1972 Traffic Volumes on California State Highways, 1972.

a/ Entries in January and August represent resident-days which are assumed constant for all months for each demand point.

